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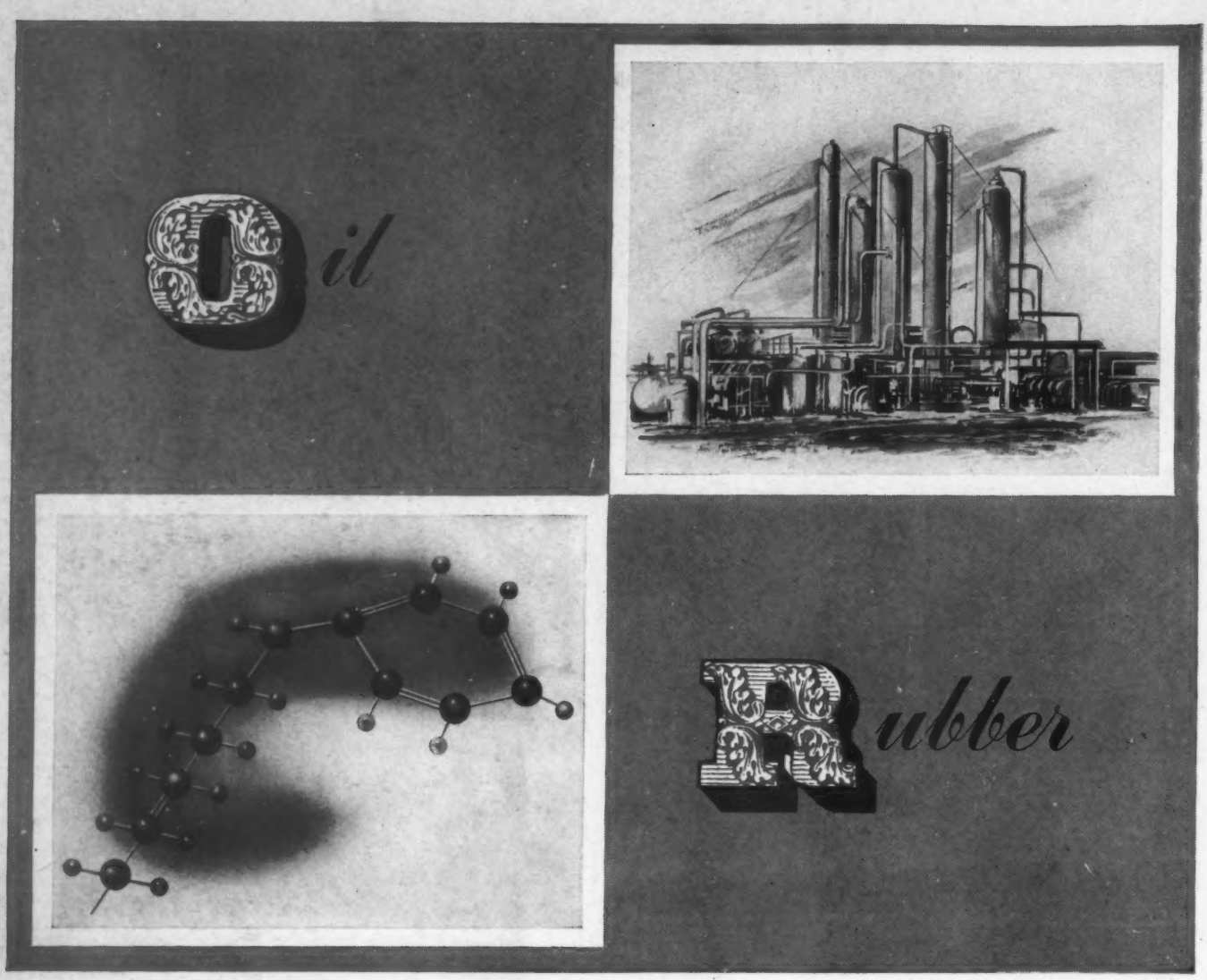

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PETROLEUM REFINER

SPECIALIZED FOR THE OIL REFINING INDUSTRY, INCLUDING PETRO-CHEMICAL ENGINEERING, PETROLEUM SYNTHETICS AND NATURAL GASOLINE

JANUARY, 1944
Vol. 23, No. 1

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Editor

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CONTENTS

Aviation Gasoline Plant Construction Will Be Completed in 1944 83

The Genesis of a Giant 91
Robert P. Russell

The Electron Tube—Geni, Gremlin or Jeep? 96
W. D. Cockrell

Spirit of the Times 101

Economics of Combustion 105
Edwin L. Dennis

Compressed Air Institute Urges More Complete Use of Compressor Auxiliaries 114

Foreign Processes for the Conversion of Methane to Hydrogen and Carbon Monoxide 117
Heinz Heinemann

Pressure Distillate Stabilizer and Butane Recovery Unit Come Out of Junk Heap 119

Maintaining Required Clearances in Centrifugal Pumps 121
Elton Sterrett

Progress of the Liquefied Petroleum Gas Industry in 1943 124
G. G. Oberfell

PIWC Stresses Free Enterprise in Worldwide Oil Development .. 132

Report on Lend-Lease Shows United States Biggest Oil User in War 139

Digest of U. S. Patents on Catalytic Hydrogenation of Hydrocarbons 154
Heinz Heinemann

Departments

Look Box 81

Science and Technology 166
E. H. Leslie and H. B. Coats

New Equipment 202

Business Notes 211

Catalogs and Bulletins 219

Advertisers' Index 222

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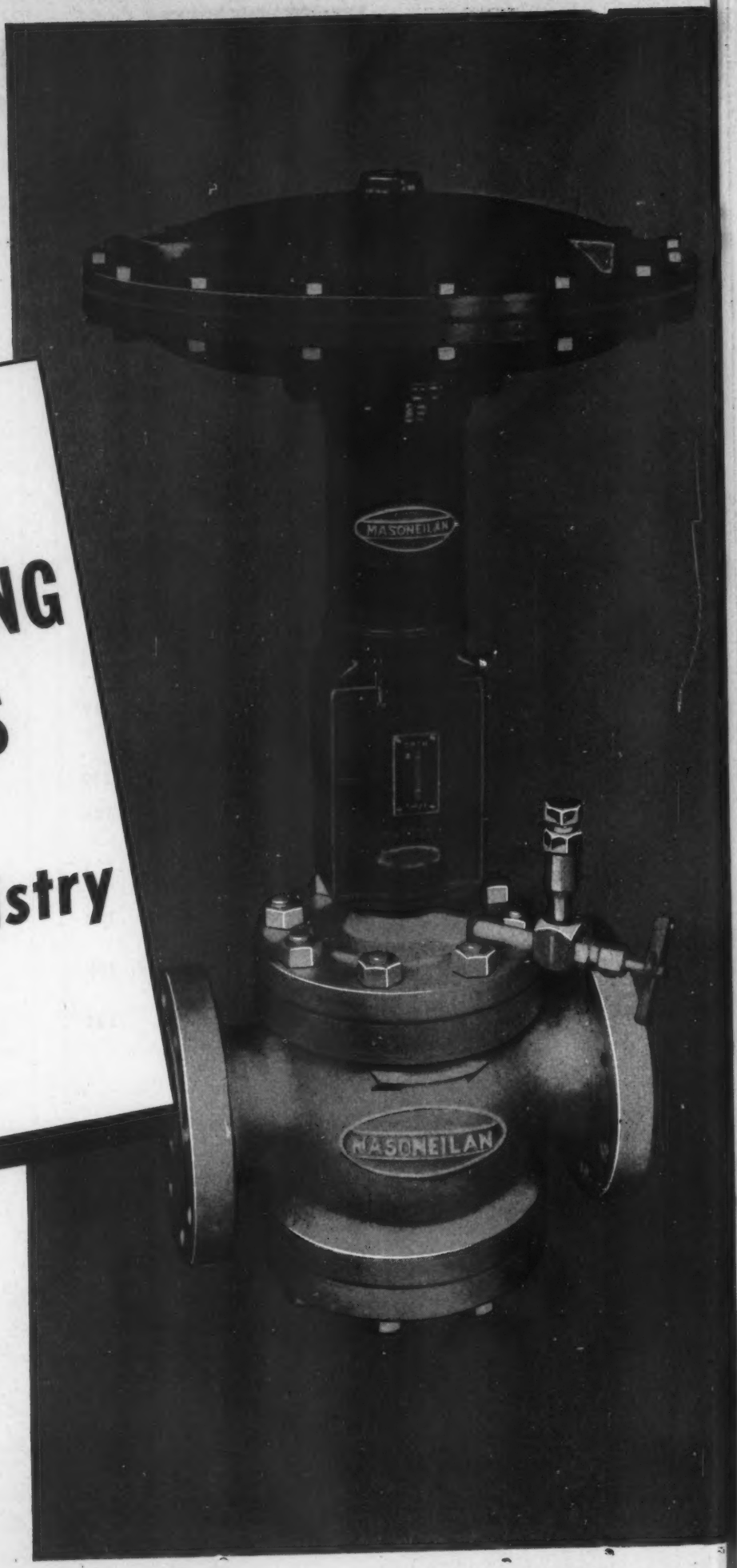

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E. Engin. Talon

PETROLEUM
REFINER

SPECIALIZED FOR THE OIL REFINING INDUSTRY, INCLUDING PETRO-CHEMICAL ENGINEERING, PETROLEUM SYNTHETICS AND NATURAL GASOLINE

A GULF PUBLISHING COMPANY PUBLICATION

THE LOOK BOX

AS THE refining industry winds up its major construction program it is laying down the foundation for its place in chemical processing. Its accomplishments in providing aviation motor fuels, ingredients for synthetic rubber and explosives are of such magnitude that it is difficult to appreciate accomplishments which are told in smaller totals. By the time the big construction jobs for the critical war products have been finished this year at least $1,500,000,000 will be represented in the new plants.

Only the Beginning

While dealing with such totals it is easy to overlook the fact that the foot soldier can traverse the jungles in a semblance of comfort because of lotions for killing insects as well as an antidote for the fungus known as athlete's foot. So long as war rages the destruction wrapped up in a gallon of toluene holds high rank. Of more benefit to mankind, however, may be the petroleum ingredient that lulls a patient into the unconsciousness essential to the operating room.

The little things mixed into the war program may remain small if interpreted in barrels. By other measures they will be large. This paragraph from a booklet, "Petroleum Research," published by Gulf Refining Company, singles out one development:

"Production of plastics from petroleum has been speeded amazingly by the war. For the post-war home, plastics may be molded into round corners which will not collect dust. Shatterproof windows, unlike glass, will admit beneficial ultra-violet rays and these same plastic windows may be created in odd shapes to suit the whim and pocketbook of the home owner. There'll be everything else from plastic conduits to fly screens that won't rust. Rays from concealed lights will flow through solid plastic conveyors, around corners and into rooms.

"Milady will wear stockings and clothing derived from oil instead of having the cocoon of a Japanese silkworm fashioned to fit her legs. And her face creams, hair oil and hand lotions now derived from petroleum may have even more attractive properties than they have today."

In the past three years the refining industry has been spending and learning. When its attention can be taken from materials for destruction, it will be ready to provide materials for human comfort.

IN OIL this nation is pouring out its full share of war energy by the day. More than 4,000,000 barrels goes through its refining plants over the span of two trips of the hour hand around the clock dial. It takes a lot of oil to prosecute a war.

Strange Reward

Although this exorbitant consumption of a valuable resource is distressing, no one would lessen it at the expense of victory. Oil is simply another resource that must be thrown into battle without regard to future consequence.

What is distressing is to realize that the contribution of oil is twisted into a basis for seeking to have government engage in the business of pro-

ducing and refining oil. Substantial parts of the consumption of oil in this country take place in countries where government has striven to explore, produce and refine oil. No government has matched the accomplishments of individuals and corporations in the United States.

Still the plea for shoving the government into the petroleum industry is that private enterprise is not capable of accomplishing what government promises.

Spirit of The Times

ELSEWHERE in this issue of PETROLEUM REFINER in the article "Spirit of the Times," the reader will come upon this unobstructive sentence:

"The cost of molasses or grain alone is, at present, higher than the cost of the finished petroleum alcohol."

It is a prophetic statement of fact. Since the butadiene program was started claims have been numerous that it could be more quickly and more cheaply produced by grain fermentation of ethyl alcohol. When the cost of butadiene from grain continued to show high cost, the return to molasses as a source material was offered as future assurance of low-cost synthetic-rubber ingredients.

All the while the petroleum industry was busy with processes and equipment by which finished ethyl alcohol can be made at a lower cost than the raw material of other sources.

There are many who believe that ethyl alcohol will prove to be the better and cheaper source of butadiene. If so, the petroleum industry still is capable of providing the best and cheapest source of butadiene.

Cooperative Privileges

IF CO-OPERATIVE refinery ownership had its roots either in more efficient management or in technical advancement, the trend could be accepted as beneficial. Few question gains made through providing cheaper or superior merchandise, provided handicaps are identical. Such a scheme is known as fair competition and its consequences are accepted as progress.

Co-operative ownership, unfortunately, enjoys special privilege. It is financed by federal funds and at low interest rates. In addition it is immune to some federal taxes. They amount to an advantage which is driving substantial private endeavor from the refining industry, as some recent sales prove. Plant owners have looked at their handicaps and taken their capital out of the business.

This is no condemnation of co-operative ownership. If the consumers of a product desire to own facilities for making and distributing it, they have that privilege. If such management proves more efficient than stockholder ownership (all handicaps being equal), it deserves what it gains.

The co-operative offers a lower price tag as evidence of its lower costs. But the lower selling price all too often is not equal to advantages of the federal treasury. If consumers put up their own money either from savings or borrowings and paid all taxes, they could not fly the lower price tag. Furthermore they would be compelled to maintain reserves for those periods when merchandise fails to meet all costs. Their operation is such that the federal treasury is too convenient to permit worry over a reserve fund.

So much federal money has been poured into industry as a war policy that pointing a finger at the co-operative may draw some smiles. It is worth noting that the refining industry has drawn from its own pocket more than half the money for building the plants that made 100-octane aviation gasoline. As an industry, refining, like other phases of oil, prefers to get its funds through private channels and pay its taxes, however loud its complaint.

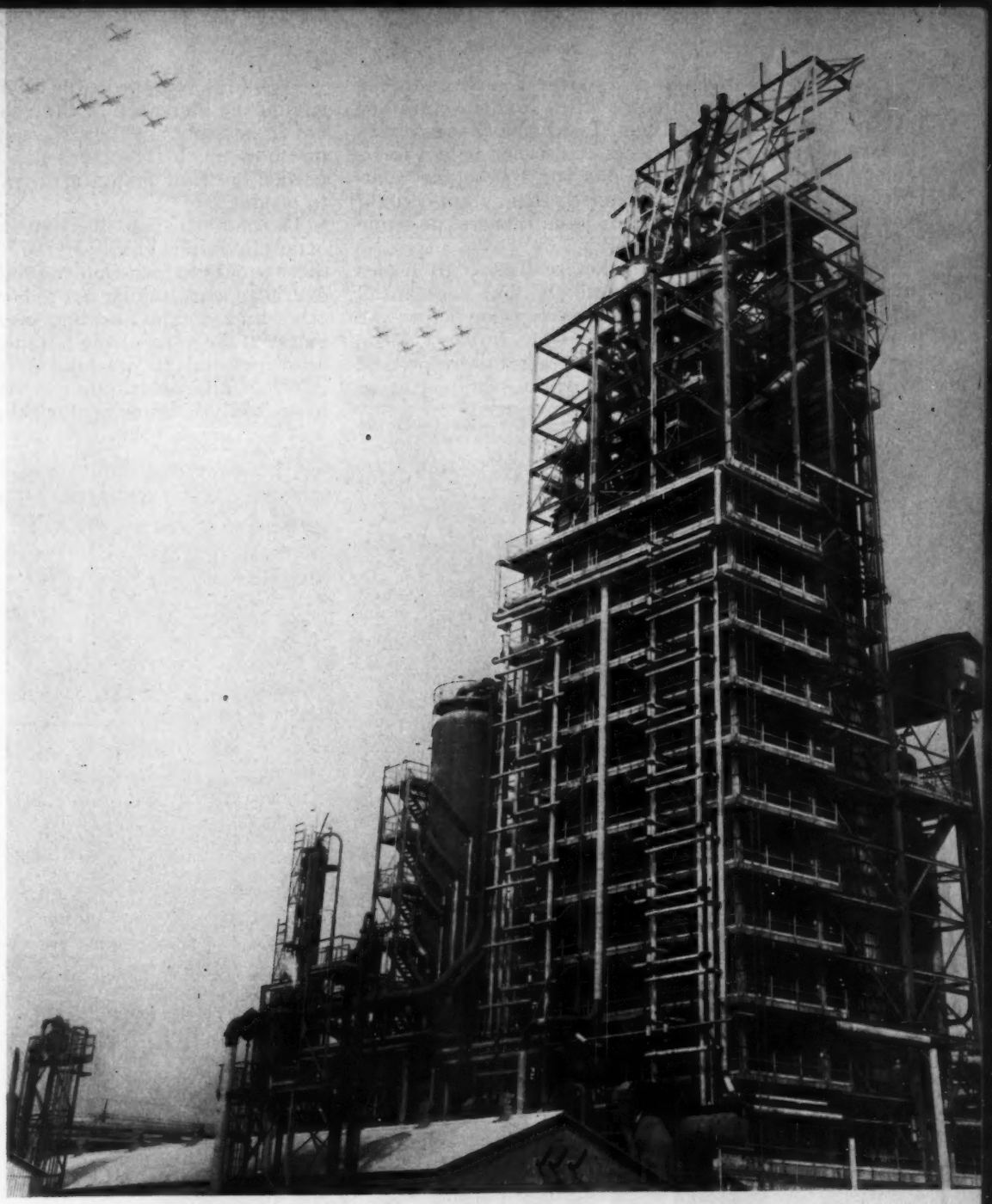
Co-operative ownership is not new. It has controlled refining plants for several years. Recently the number of plants to go under co-operative ownership has increased sharply. No doubt the increase in federal taxes is widening the distance between the two types of management.

Cost of Canol

CONFLICTING attitudes as to the wisdom of the Canol project are reasonable. The viewpoint of a general, who anticipates invasion, is not the attitude of a civilian who fears no invasion. Drawing a bead on truth under such circumstances is difficult.

Regardless of viewpoint, it is not understandable that any man or men can justify the cost of the project. Norman Wells oil could have been brought to Whitehorse for far less money. The millions involved in the development are fantastic.

It is unfortunate that the American public accepts such squandering without complaint. The military should be reminded frequently that the winning of a war does not require disregard of cost.



Army airplanes over a TCC unit in the Beaumont plant of Magnolia Petroleum Company.

Aviation Gasoline Plant Construction Will Be Completed in 1944

IN 1944 the refining industry will complete its major construction accomplishment—provision of facilities for making aviation-grade motor fuels.

Core of this program is the 94 plants which will make all ingredients and blend them into 100-octane aviation gasoline. Currently 32 of these units are operating; 40 will go on stream during the next three months; 22 are scheduled for completion later in the year.

The full program, however, involves more than 300 plants. The additional units are making aviation gasolines of octane rating lower than 100 or furnishing ingredients to plants which finish the several aviation-grade fuels. Natural-gasoline and cycling plants are included in this plant list.

The construction represents an expenditure in excess of $900,000,000—more than the cost of all phases of the synthetic-rubber program.

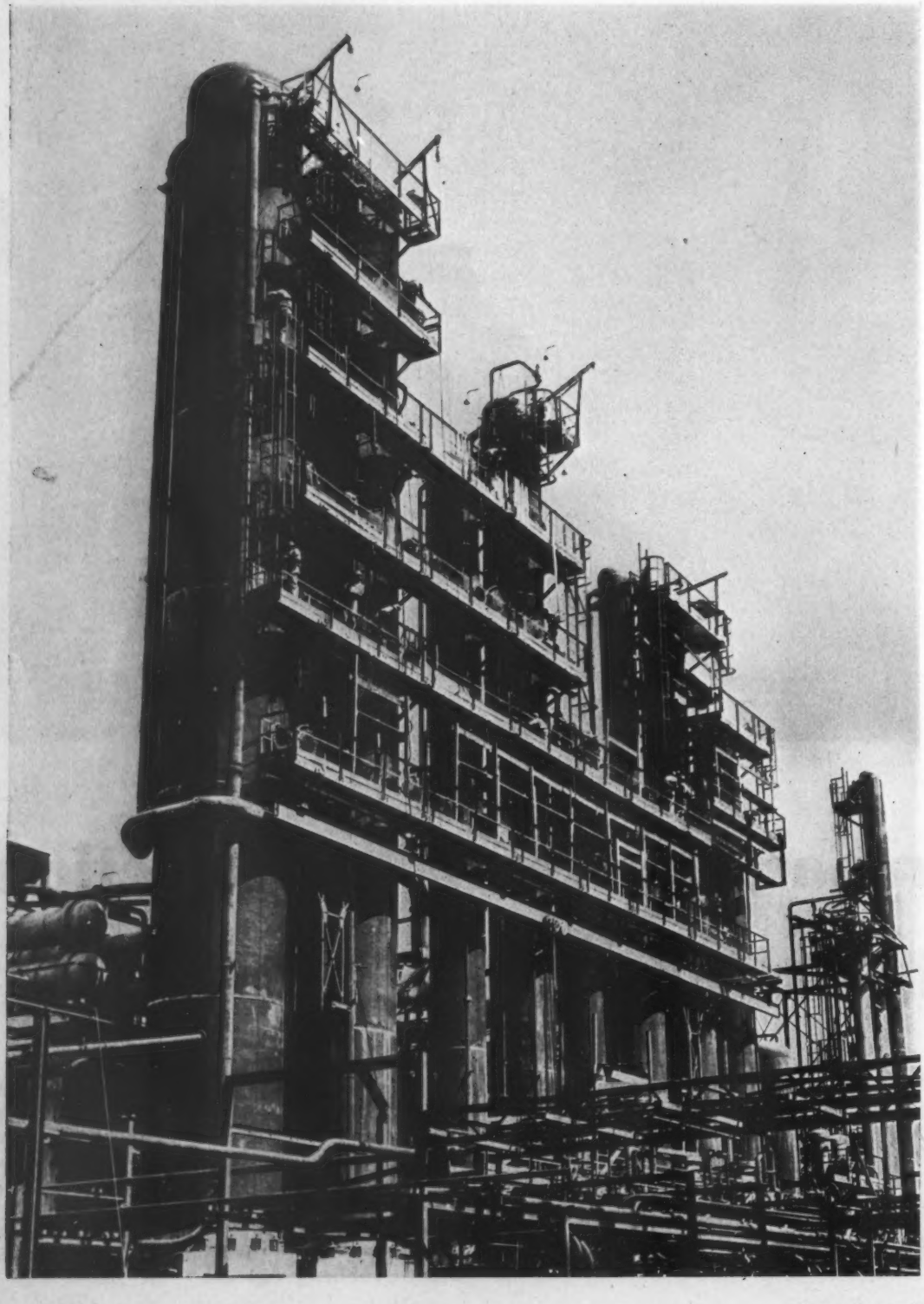
Facilities of this magnitude are the answer to the demand for aviation motor fuel for the military forces of the United Nations. Twice the program was increased from military necessity; twice it had to be enlarged because specifications for 100-octane aviation gasoline were so changed that plants could process less of the ingredients from a barrel of crude oil.

The fortunes of war will dictate further increases in plant facilities but it is unlikely that substantial additions will be necessary. In their paper before the Society of Automobile Engineers December 2, 1943, Bruce K. Brown, assistant deputy administrator, and D. P. Barnard, consultant, Petroleum Administration for War, gave this estimate of future needs:

"While it is improbable that there will be further significant increases in the requirement figures, it is not impossible and hence we do not know definitely just how much 100-octane gasoline will ultimately be needed nor how many facilities we are going to build to produce it."

The catalytic cracking unit is the foundation of 100-octane aviation gasoline. Its base stock comes from these processes, which also produce the butane-butene overhead cuts which are converted to alkylate and other high-octane blending ingredients. Butylene, the material for most of the butadiene, also is taken overhead for catalytic cracking units.

When all construction is complete 60 plants will have catalytic cracking facilities. Under the stress of



Alkylation unit in the Smith Bluff plant of Pure Oil Company, which will operate the equipment, which is owned by Defense Plant Corporation.

Status of the Aviation Gasoline Plant Construction Program

COMPANY AND PLANT LOCATION	STATUS OF PROCESSES	
	OPERATING	BUILDING
J. S. Abercrombie and Magnolia Petroleum Company, Sweeny, Texas		Fluid Catalytic Alkylation Isomerization
The Atlantic Refining Company, Atreco, Texas		Fluid Catalytic Alkylation
The Atlantic Refining Company, Philadelphia, Pennsylvania	Alkylation	Fluid Catalytic
Ashland Oil & Refining Company, Ashland, Kentucky		Thermofor Catalytic Alkylation Isomerization
Associated Refineries, Inc., Duncan, Oklahoma		Fluid Catalytic Alkylation Isomerization
Champlin Refining Company, Enid, Oklahoma		Alkylation Isomerization
Cities Service Oil Company, East Chicago, Indiana	Alkylation Isomerization	
Cities Service Oil Company, Lake Charles, Louisiana		Fluid Catalytic Alkylation Isomerization
Continental Oil Company, Ponca City, Oklahoma	Hydroforming	Thermofor Catalytic Alkylation Isomerization
Continental Oil Company, Lake Charles, Louisiana	Alkylation	
Continental Oil Company, Wichita Falls, Texas	Alkylation	
Crown Central Petroleum Corporation, Houston, Texas		Thermofor Catalytic Alkylation Isomerization
Eastern States Petroleum Corporation, Houston, Texas		Fluid Catalytic Alkylation Isomerization
Frontier Refining Company, Cheyenne, Wyoming		Fluid Catalyst Alkylation Isomerization
General Petroleum Corporation, Torrance, California		Thermofor Catalytic Alkylation
Great Southern Corporation, Corpus Christi, Texas		Dehydrogenation Alkylation
Gulf Oil Corporation, Port Arthur, Texas	Houdry Catalytic Thermofor Catalytic Alkylation Isomerization Hydrogenation	Isomerization
Humble Oil & Refining Company, Baytown, Texas	Fluid Catalytic Alkylation Isomerization	Fluid Catalytic Hydrogenation
Magnolia Petroleum Company	Thermofor Catalytic Houdry Catalytic Alkylation	
Mohawk Petroleum Corporation, Bakersfield, California		Alkylation Isomerization
National Refining Company, Coffeyville, Kansas		Fluid Catalytic Alkylation Isomerization
Pan American Refining Corporation, Texas City, Texas	Alkylation Hydroforming	Fluid Catalytic Isomerization
Pennzoil Company, Oil City, Pennsylvania		Fluid Catalytic Alkylation Isomerization.
Phillips Petroleum Company, Borger, Texas	Alkylation	Cycloversion Isomerization
Phillips Petroleum Company, Oklahoma City, Oklahoma	Hydrogenation Isomerization	
Phillips Petroleum Company, Kansas City, Kansas	Alkylation	Isomerization
Pure Oil Company, Nederland, Texas	Alkylation	Thermofor Catalytic
The Pure Oil Company, Toledo, Ohio		Hydroforming
Richfield Oil Corporation	Alkylation Isomerization	Thermofor Catalytic
Republic Oil Refining Company, Texas City, Texas		Fluid Catalytic Alkylation
Root Petroleum Company		Fluid Catalytic Alkylation Isomerization
Premier Oil Refining Company		Alkylation Dehydrogenation
Shell Oil Company, Wood River, Illinois	Alkylation Hydrogenation	Fluid Catalytic Hydrogenation Isomerization
Shell Oil Company, Wilmington, California	Fluid Catalytic Hydrogenation	Alkylation Hydrogenation Isomerization
Shell Oil Company, Martinez, California	Alkylation	
Shell Oil Company, Houston, Texas	Alkylation Hydrogenation Isomerization	
Shell Oil Company, Norco, Louisiana	Alkylation	
Sinclair Refining Company, Corpus Christi, Texas		Houdry Catalytic Alkylation
Sinclair Refining Company, Sinclair, Wyoming		Fluid Catalytic Alkylation Isomerization
Sinclair Refining Company, Houston, Texas	Houdry Catalytic Alkylation	Thermofor Catalytic
Socony-Vacuum Oil Company, East St. Louis, Illinois	Houdry Catalytic	Thermofor Catalytic Alkylation
Socony-Vacuum Oil Company, East Chicago, Indiana	Houdry Catalytic	
Socony-Vacuum Oil Company, Augusta, Kansas	Houdry Catalytic Alkylation	
Socony-Vacuum Oil Company, Paulsboro, New Jersey	Houdry Catalytic	Thermofor Catalytic Alkylation
Socony-Vacuum Oil Company, Buffalo, New York	Houdry Catalytic	
Socony-Vacuum Oil Company, Brooklyn, New York	Houdry Catalytic	
Socony-Vacuum Oil Company, Trenton, Michigan	Houdry Catalytic	
Southport Petroleum Company, Texas City, Texas		Houdry Catalytic Alkylation
Standard Oil Company of California, El Segundo, California	Houdry Catalytic Alkylation Isomerization	
Standard Oil Company of California, Richmond, California	Hydroforming Alkylation Hydrogenation	
Standard Oil Company (Indiana), Whiting, Indiana	Hydroforming Hydrogenation	Alkylation Isomerization Isomate
Standard Oil Company (Indiana), Wood River, Illinois		Fluid Catalytic Alkylation Isomerization
Standard Oil Company of Louisiana, Baton Rouge, Louisiana	Fluid Catalytic Alkylation Hydrogenation Isomerization	
Standard Oil Company of New Jersey, Bayway, New Jersey	Fluid Catalytic	
Standard Oil Company of New Jersey, Baltimore, Maryland	Fluid Catalytic Alkylation	
The Standard Oil Company (Ohio), Cleveland, Ohio		Houdry Catalytic
The Standard Oil Company (Ohio), Toledo, Ohio	Alkylation	
Sun Oil Company, Marcus Hook, Pennsylvania	Houdry Catalytic Alkylation	Thermofor Catalytic
The Texas Company, Port Arthur, Texas	Alkylation Isomerization	Fluid Catalytic
The Texas Company, Lockport, Illinois	Hydroforming Alkylation Isomerization	
The Texas Company, Wilmington, California	Alkylation	Fluid Catalytic
Tide Water Associated Oil Company, Avon, California	Alkylation Isomerization	Fluid Catalytic Isomerization
Tide Water Associated Oil Company, Bayonne, New Jersey	Houdry Catalytic	Thermofor Catalytic
Union Oil Company, Wilmington, California	Thermofor Catalytic Alkylation	Isomerization
Utah Oil Refining Company		Fluid Catalytic Alkylation Isomate Isomerization
Wilshire Oil Company		Fluid Catalytic Alkylation Isomerization
FOREIGN		
Asiatic Petroleum Corporation, Curacao, N.W.I.		Alkylation Isomerization
Bahrein Petroleum Company, Bahrein Island		Alkylation
Imperial Oil, Ltd., Calgary, Alberta, Canada	Alkylation	
Lago Oil & Transport Company	Alkylation Isomerization	Fluid Catalytic
Shell Oil Company, Montreal, Canada		Alkylation

PLANTS CONTRIBUTING TO THE AVIATION GASOLINE TOTAL

Although all plants for making 100-octane aviation gasoline will be completed this year, it is likely that as many more will continue to provide one or more ingredients for these motor fuels.

Refining plants, natural gasoline plants and cycling plants have parts in furnishing these products to the larger plants, where the motor fuels are completed. The contribution of the smaller refining plants came about largely through the conversion of polymerization units to the making of cumeme. Natural gasoline and cycling plants are providing both normal and iso-butane and iso-pentane.

Plants in this phase of the aviation-gasoline program will grow in number. Those now contributing one or more ingredients are:

American Mineral Spirit Company,
Corpus Christi, Texas.

Arkansas Fuel Oil Company,
Shreveport, Louisiana.

Atlas Oil & Refining Company,
Shreveport, Louisiana.

Aurora Gasoline Company,
Detroit, Michigan.

Bareco Oil Company,
Wichita, Kansas.

Bay Petroleum Company,
McPherson, Kansas.

Bell Oil & Gas Company,
Ardmore, Oklahoma.

Ben Franklin Refining Company,
Ardmore, Oklahoma.

Camoil Company,
Hanford and Santa Fe Springs, California.

Colonial Beacon Oil Company,
Everett, Massachusetts.

Col-Tex Refining Company,
Colorado City, Texas.

Continental Oil Company,
Glen Rock, Wyoming.

Cooperative Refinery Association,
Phillipsburg, Kansas.

Cosden Petroleum Corporation,
Big Spring, Texas.

Cushing Refining and Gasoline Company,
Cushing, Oklahoma.

Danciger Oil & Refineries,
Pampa, Texas.

Deep Rock Oil Corporation,
Cushing, Oklahoma.

Derby Oil Company,
Wichita, Kansas.

Distillate Production Company,
Houston, Texas.

El Dorado Refining Company,
El Dorado, Kansas.

Farmers' Union Central Exchange,
Laurel, Montana.

Freedom Oil Works,
Freedom, Pennsylvania.

Glazier Production Company,
Cut Bank, Montana.

Globe Oil & Refining Company,
Lemont, Illinois.

Hagy, Harrington and Marsh,
Amarillo, Texas.

Hamman Exploration Company,
Bay City, Texas.

Humble Oil & Refining Company,
Ingleside and San Antonio, Texas.

Hunt Oil Company,
Palestine, Texas.

Independent Refining Company,
Arp, Texas.

Inland Empire Refineries,
Spokane, Washington.

Johnson Oil Refining Company,
Cleveland, Oklahoma.

Kanotex Refining Company,
Arkansas City, Kansas.

Kendall Refining Company,
Bradford, Pennsylvania.

Latonia Refining Corporation,
Covington, Kentucky.

Leonard Refineries, Inc.,
Alma and St. Louis, Michigan.

Lone Star Producing Company,
Ranger, Texas.

Louisville Refining Company,
Louisville, Kentucky.

Macmillan Petroleum Corporation,
Signal Hill, California.

Magnolia Petroleum Company,
Fort Worth, Texas.

Malco Refineries, Inc.,
Artesia, New Mexico.

McMurrey Refining Company,
Tyler, Texas.

Maritime Oil Company,
Houston, Texas.

Mid-West Refineries, Inc.,
Alma and Grandville, Michigan.

National Refining Company,
Findlay, Ohio.

Northwest Refining Company,
Cut Bank, Montana.

Ohio Oil Company,
Robinson, Illinois.

Old Dutch Refining Company,
Muskegon, Michigan.

Pennzoil Company,
Oil City, Pennsylvania.

Phillips Petroleum Company,
Okmulgee, Oklahoma.

Pontiac Refining Corporation,
Corpus Christi, Texas.

Pure Oil Company,
Newark and Heath, Ohio; Cabincreek, West Virginia.

Quaker State Oil Refining Corporation,
Emlenton and Farmers Valley, Pennsylvania.

Rock Island Refining Company,
Duncan, Oklahoma.

Sinclair Refining Company,
Coffeyville and Kansas City, Kansas; Marcus Hook, Pennsylvania.

Skelly Oil Company,
El Dorado, Kansas.

Southwestern Oil & Refining Company,
Corpus Christi, Texas.

Standard Oil Company of California,
Bakersfield, California.

Standard Oil Company of Indiana,
Sugar Creek, Missouri.

Standard Oil Company of Ohio,
Lima, Ohio.

Standard Oil Company of Texas,
El Paso, Texas.

Sun Oil Company,
Toledo, Ohio.

Sunray Oil Company,
Allen, Oklahoma.

Superior Oil Company,
Conroe, Texas.

Taylor Refining Company,
Corpus Christi, Texas.

The Texas Company,
Lawrenceville, Illinois; West Tulsa, Oklahoma; Dallas, Texas.

Tide Water Associated Oil Company,
Drumright, Oklahoma.

Union Oil Company,
Bakersfield, Maltha and Oleum, California.

United Refining Company,
Warren, Pennsylvania.

Vickers Petroleum Company,
Potwin, Kansas.

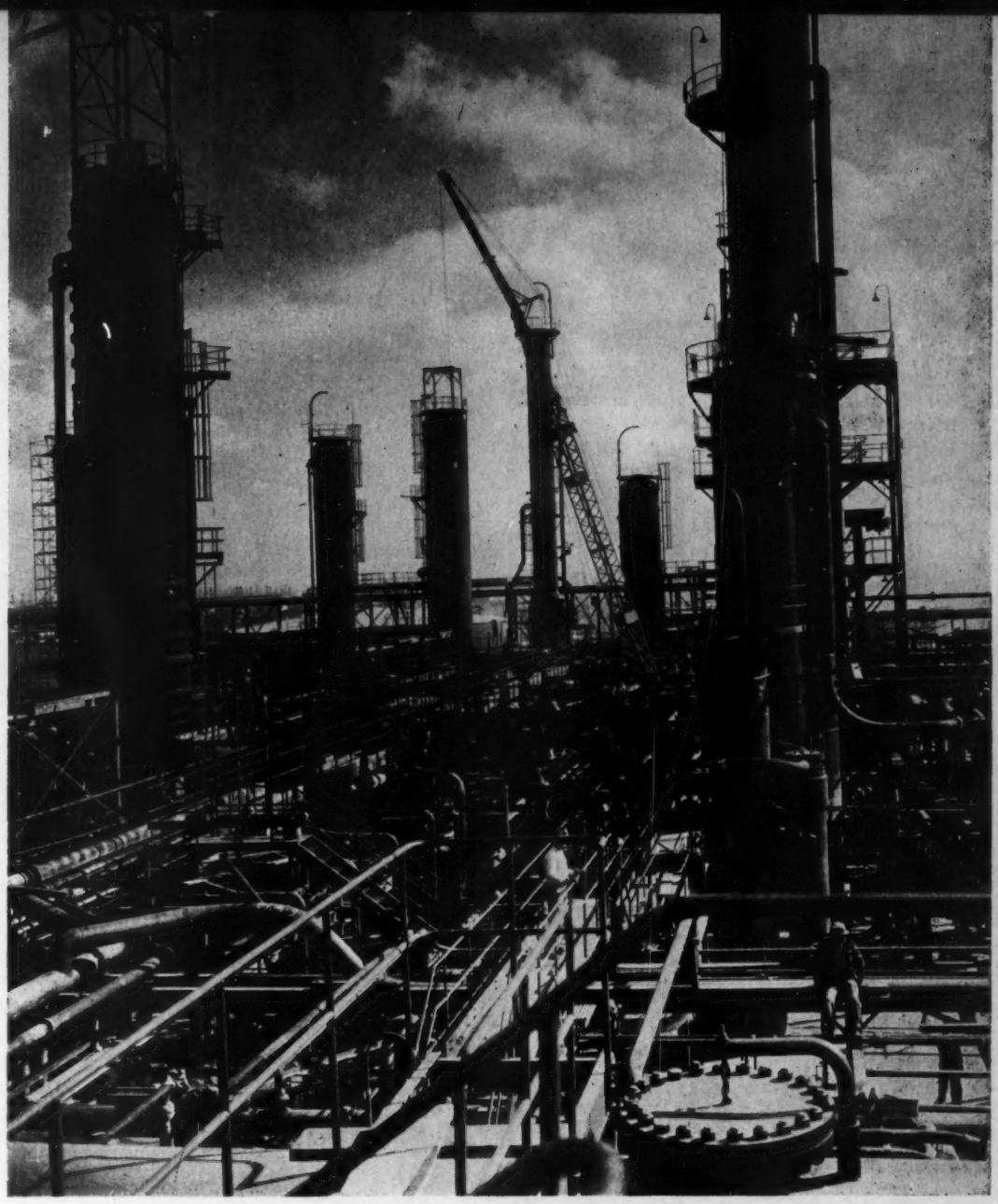
Waggoner Refining Company,
Electra, Texas.

Wasatch Oil Refining Company,
Woods Cross, Utah.

Wilcox Oil & Gas Company,
Bristow, Oklahoma.

Wilshire Oil Company,
Los Angeles, California.

Wood River Oil & Refining Company,
Hartford, Illinois.



Fractionation towers in the Combination cracking unit, a part of the aviation gasoline facilities of Union Oil Company in California.

operation to produce base stock for 100-octane aviation gasoline, the combined daily capacity of all catalytic units will be 760,000 barrels daily. This figure, 60 plants, does not check with statistics as to catalytic units, since some plants have more than one catalytic unit, a few have units of different processes.

There were only 14 catalytic cracking units in operation in December 1941 and only 22 plants were making 100-octane aviation gasoline two years ago.

Aviation-grade fuels of octane rating lower than 100 are the backbone of the military training program, consequently the production of fuels of these grades is widespread, with more than 200 plants, some making the gasoline and others providing one or more ingredients, engaged in the activity. The full scope of the aviation-motor-fuel program recently was thus outlined by Ralph K. Davies, Deputy Petroleum Administrator for War:

"In addition to the complete plants, the Petroleum Administration for War has initiated more than 200 other projects for changing or expanding existing facilities to increase 100-octane-gasoline production as well as other high-octane aviation gasolines, which are needed in tremendous quantities for military training.

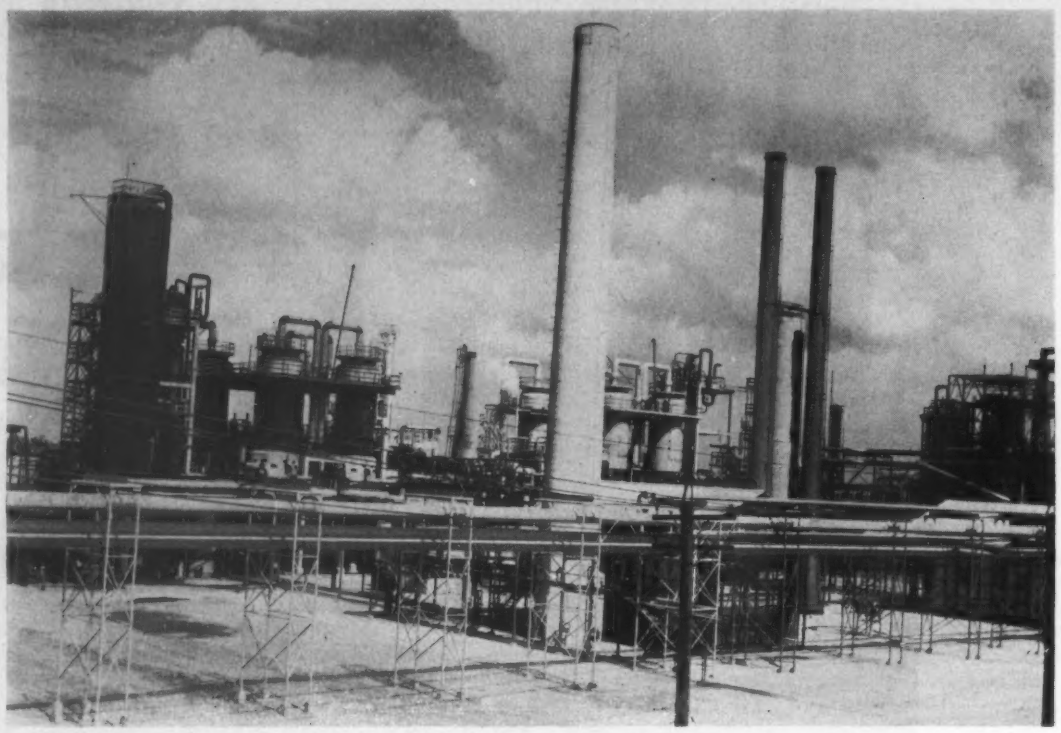
"These projects vary from small conversion jobs, costing less than $10,000, to complete plants, costing several millions and include two complete refineries. The new plants which in nearly all cases are being erected within existing refineries are scattered throughout the country, with the heaviest concentration in the Southwest where 40 percent of the plants are being built.

"Both large and small refineries are participating in the program under the guidance of PAW, patents and engineering knowledge were pooled and in many cases engineering staffs of large companies, which had developed processes for making 100-octane gasoline, were loaned to companies which before the war had not made the product."

From the first output of aviation motor fuel has exceeded calculations. Detailed figures are not made public. In November PAW gave this information:

"Present production exceeds the 1944 goal of ultimate requirements as set by the military and government authorities in the spring of 1942."

The output is four times as great as it was two years ago and with the completion of plants in the first quarter of this year will be eight times the output the corresponding period of 1942.



New Houdry catalytic units

Keeping output ahead of demand called for ingenious devices which have been summed up as follows:

"During the period of plant construction the growing demand for 100-octane gasoline was met in several ways. Change in the specifications to permit use of slightly more tetraethyl lead, elimination of bottlenecks through integration of refinery operation on a national basis and development of new blending agents were among the means taken to boost production ahead of completion of the construction program."

One of the approaches to increasing supply has been explained by Ralph K. Davies:

"Before the war facilities for making a valuable 100-octane component called hydrocodimer had not been widely developed because the newer and cheaper process of alkylation was superseding the making of hydrocodimer. The resulting component or blending agents are nearly identical.

"When the urgent need for maximum production of 100-octane developed, it was imperitive that we use all possible methods of producing the product and immediately undertook the expansion of hydrocodimer production.

"Hydrocodimer is simply a process of adding two atoms of hydrogen to one molecule of a product called codimer. This is done in a hydrogenation plant. Fortunately where two such plants in the country, which, though busy at making other petroleum products for war, could be quickly converted to making hydrocodimer.

"The problem then was to develop the supply of codimer. We found that this could be produced by asking between 70 and 80 gasoline refiners to change the method of operating polymerization units which were then producing motor gasoline. By this simple change we could multiply many fold the production of codimer and thereby the production of hydrocodimer, since the two hydrogenation plants could readily process the entire codimer output of the gasoline plants.

"Each barrel of hydrocodimer is estimated to be equivalent to about two to three barrels of 100-octane gasoline in the sense that one barrel of this high quality ingredient can be mixed with one to two barrels of gasoline to produce two to three barrels of 100-octane gasoline. The minor necessary refinery conversions were quickly and cheaply made."

Cost of the aviation-gasoline plants will exceed $900,000,000.

More than 75 percent of the total will come from private financing. This attitude is typical of the petroleum industry, which leads all others in the amount of its own money put into war production. The record of all expenditures for war purposes by major industries as compiled by the National Industrial Conference Board is:

Industry	Private	Government
Petroleum	58.8	41.2
Machine Tools	44.2	55.8
Miscellaneous Manufacturing	40.3	59.7
Machinery	35.7	64.3
Iron and Steel	28.6	71.4
Nonferrous Metals	21.7	78.3
Chemicals	18.5	81.5
Combat and Motorized Vehicles	13.7	86.3
Guns	9.6	90.4
Ammunition	9.2	90.8
Aircraft	7.0	93.0
Shipbuilding	4.0	96.0
Explosives	.4	99.6

The processing equipment for making aviation-grade motor fuels have been inserted into existing refining plants. This influence recently was thus out-

lined through the office of PAW as, "the utilization of existing equipment wrote the specifications for most of the 94 major 100-octane construction projects initiated by the Petroleum Administration for War."

"The magnitude of the rush construction job," added Ralph K. Davies, "becomes forcefully apparent when it is realized that each plant is an individual building and engineering achievement. Each is adapted as to size, operation and special refining processes to the quality of crude available and products to be manufactured. Each added unit must be geared to the equipment already in operation. The new 100-octane plant which has just gone on stream at Houston varies in size, operational method and refining processes from the plant completed at Baltimore last month.

"Drastic modifications were necessary in the installation of a catalytic cracking plant at one Southwest refinery in order to scale operations of the new unit to existing equipment, an old style thermal-cracking unit. The capacity of another refinery, determined years ago by the crude supply obtainable, indicated the type of new unit required to make an aviation-gasoline component."

This PAW news release gave this additional explanation:

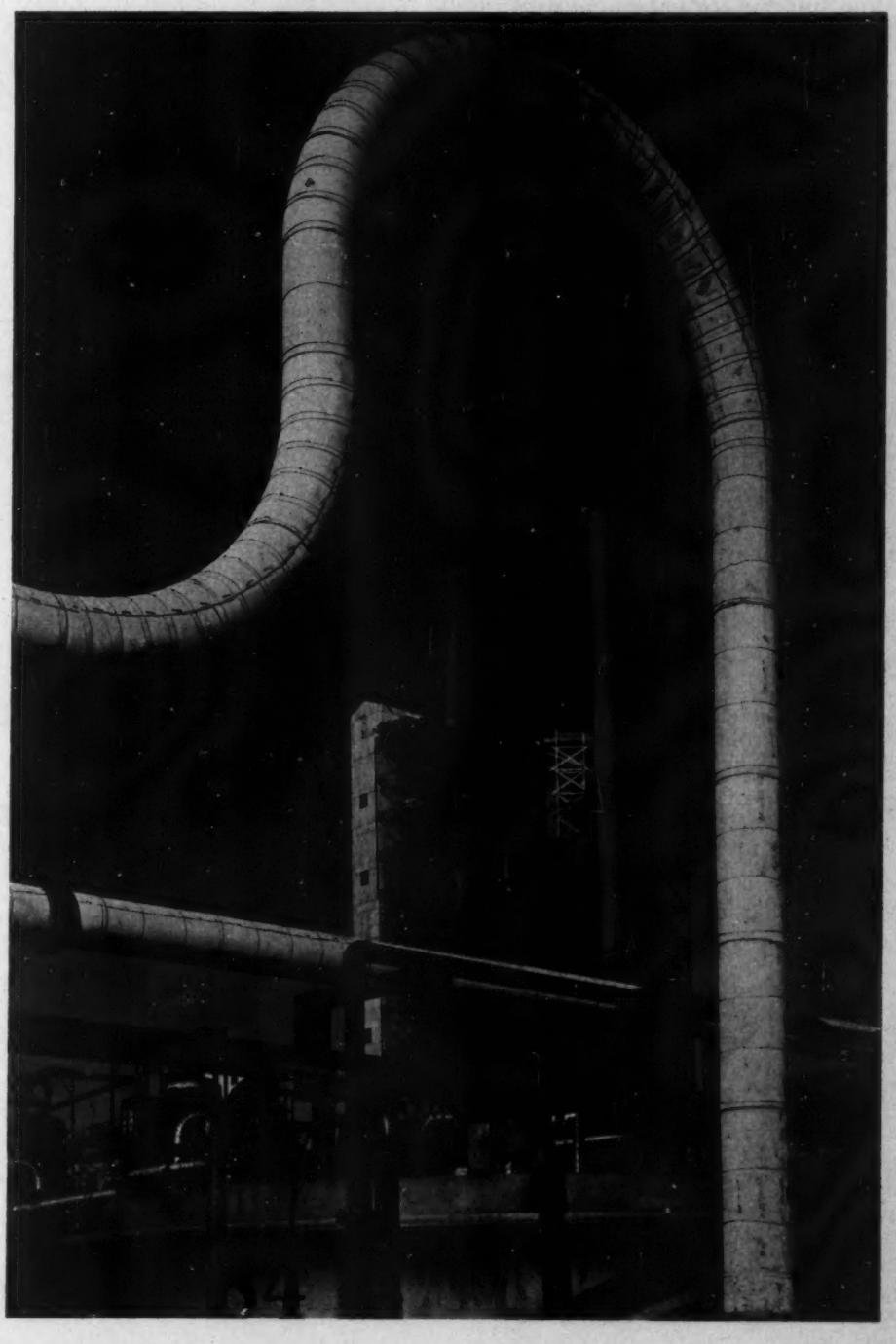
"The complex steps in the processing of West Coast crudes, most of which are highly viscous, differ sharply from steps taken to extract the utmost aviation base stock from the lighter, more volatile Pennsylvania crudes. The original crude feed determines the character of the gasoil base stock from a plant and also the resultant thermal gas. These in turn affect the operation of the newly added aviation gasoline units.

"The super fractionation of high-quality base stocks to obtain a larger volume of aviation fuel called for radical changes in the design for the fractionating tower of a refinery at Baytown. The extreme humidity of the air on the Gulf Coast requires the construction of much higher cooling towers than for plants in East Chicago. The difference in temperature of the cooling tower at Wood River, Illinois, and at Lake Charles, Louisiana, was sufficient to necessitate marked changes in the engineering designs of projects in those localities."

Two changes in specifications for 100-octane aviation gasoline made it necessary to enlarge the plant-construction program. Each change meant that equipment could produce less of the essential motor fuel. One improvement was made in July, 1942; the other in January, 1943. What they involved has thus been explained by the Petroleum Administration for War:

"To make these improvements would have cost the country a 34-percent loss in daily production of 100-octane gasoline if that effect had not been anticipated and counter balanced by expansion of the 100-octane-plant-construction program and by development of additional blending agents not previously used in 100-octane gasoline.

"How improvement of the product reduces production is indicated by the fact that facilities which could produce 10,000 barrels a day of prewar 100-octane would be able to produce only 6,600 barrels a day of the present product. The reduction is accounted for by the more concentrated use of certain blending agents. Though still called gasoline for convenience, 100-octane aviation motor fuel is not gasoline in the ordinary sense but super-fuel produced by



A fluid catalytic unit framed by insulated piping in the Baltimore plant of Standard Oil Company of New Jersey.

rearranging the petroleum molecules through the use of cataylsts.

"This 100-octane fuel starts with a synthetic base stock which is about equal in potential power and far superior in other qualities, to automobile gasoline that has been doctored to its limit. Aviation fuel requires hard-to-get synthetic petroleum derivatives which conventional refining can not produce and production of them reduces the amount of raw material available for making motor gasoline. Aviation fuel must be absolutely free of numerous unwanted natural impurities which are inconsequential in a motor car.

"Although automobile gasoline can be raised to a top of about 87 octane on the regular gasoline scale, it is not even the equivalent of 87-octane aviation fuel, the grade used by light civilian and training aircraft. On the other hand many of the facilities now being expanded to make aviation fuel and particularly 100 octane, can be converted to making high-octane gasoline suitable for passenger cars.

"The development of 100-octane gasoline in 1934 and the consequent improvements in the product have been pointed solely at increasing power and performance of military airplanes. Even the largest commercial airliners operate satisfactorily on only 91-octane aviation fuel, of which, if 100 octane were not needed, present facilities could make more than enough for all military and civilian needs.

"The superiority of 100-octane gasoline over 91-octane gasoline today is approximately the same as the superiority of 100-octane gasoline over 87-octane gasoline in 1941."

However striking the building accomplishment, the ingenuity by which conventional equipment was adapted to meeting more rigid gasoline specifications is even more remarkable. At the end of 1942 new refining units were providing only 14 percent of the military aviation gasoline requirement. Men had forced refining equipment into the making of products for which it never was intended. Along with that specifications had been changed and the refining industry had its "quick-100-octane program" which continued to provide more than half the gasoline of that class until the middle of 1943.

This accomplishment and its influence on refining over that period recently was discussed by Harold L. Ickes, Petroleum Administrator for War:

"Thirty-nine percent of our 100-octane production at the end of 1942 was the result of conversions and improvisions. This 39 percent of its total production also was 62 percent of the increase in 100-octane production. Without this it is easy to see that we would have experienced a serious shortage. About 16 percent of the gain was attributable to an increase in the amount of tetraethyl lead added to the product.

"By July 1, 1943 the 'quick' program was producing 44 percent of the total and new plants had increased to only 22 percent of the total.

By the fall of 1943 this situation had begun to change as new facilities of the 1942-43 construction program were completed. When this program is completed early in 1944 production from new plants will greatly exceed the production of the 'quick' program, although that program will continue in full force. Some minor expansions were made in this program late in 1943.

"The 'quick' program consisted of five steps: adoption of a new blending agent, cumeme, which could be made by existing plants after slight alterations; conversion of catalytic cracking plants to the manufacture of aviation base stock instead of motor gasoline; use of existing plants for production of a blending agent known as hydrocodimer; inter-plant movements of components of 100-octane gasoline; and technological improvements.

"Cumeme is a rich mixture additive for aviation base gasoline, produced by the conversion of benzol, also a blending agent. Sufficient quantities of benzol were at once made available for manufacture of cumeme. Plants in operation, after minor adaptations, were making as early as September, 1943, more than 6,000 barrels a day of the powerful component which had the capacity of raising the octane number of lower quality base stocks to combat-fuel specifications. Cumeme from the 18 plants currently operating has sky-rocketed the output of aviation fuel.

"Fourteen plants at the beginning of 1942 were producing automotive gasoline by the catalytic process, a new method for breaking down the molecules of petroleum and scientifically re-arranging them to manufacture a gasoline with an octane rating of about 80. Minor alterations were quickly completed which resulted in the production of aviation base stocks in large volume.

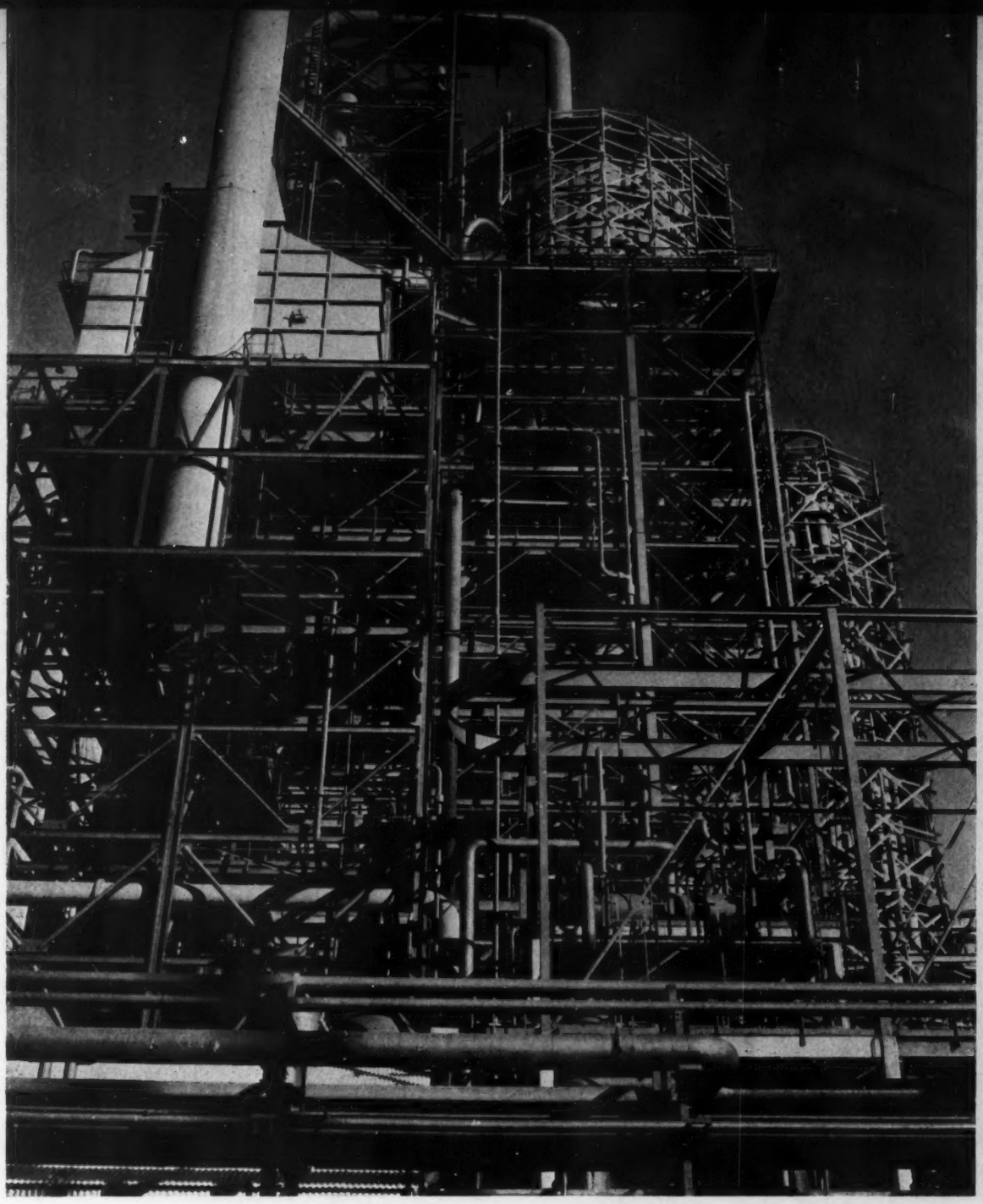
"Every refining facility was closely examined to the end that 100-octane supply be supplemented. Existing plant units which produced polymer, a blending agent for automotive gasoline, were converted to the manufacture of codimer, which when hydrogenated, becomes hydrocodimer, a powerful blending agent. Codimer is now being produced in large quantities in 72 plants, from which it is shipped to two other plants to be hydrogenated.

"Inter plant movement of component parts of 100-octane gasoline was effected by a planned blending schedule for refiners. Expert juggling of these components and elimination of bottlenecks in transportation insured maximum quantity and quality of the blended fuel. Under this plan all refineries were considered as units in one national refinery. If a surplus of a raw material for 100-octane existed in Philadelphia and a San Francisco refinery could use that raw material, it was shipped. It is estimated that some of the components of a completed barrel of 100-octane may have traveled as much as 10,000 miles.

"Improvements in operational methods of numbers of small refineries have increased the volume of fighting fuel. One small plant was enabled to manufacture aviation base stock after laying only 15 miles of pipe line to segregate the crude feeding the plant. The job was done with second-hand pipe and by existing personnel contributing man hours above the regular work week. The project cost but $20,000.

"The aviation gasoline sub-committees which were set up in each of the five PAW refining districts were particularly effective in exchanging useful information among large and small operators. All available data on patents, processes and experiments were given all manufacturers.

"The nation's extremity was a fighting challenge to our refining capacity. The oil industry proved its ability to meet a crisis by quickly completing more than 200 projects, minor and major, for the conversion and adaptation of existing refining facilities to bridge the gap in our plane fuel output until new plants could be constructed and swing into production."



The Genesis of a Giant

ROBERT P. RUSSELL, Vice President, Standard Oil Development Company

TO MOST of you the new fluid catalytic cracking plant in our Baltimore refinery may seem to be simply another, although certainly the very latest type, item of refinery equipment. I doubt very much, though, that more than a few of you have even the remotest idea of the tremendous background of research, development and engineering endeavor, involving years of hard work by literally hundreds of operators, mechanics, chemists, chemical engineers, mechanical engineers and analysts that had to be coordinated and concentrated to bring such a revolutionary technique as this into actual accomplishment. We, in the Standard Oil Development Company, which is the central research and development arm of Standard Oil Company (New Jersey), are very proud to have been so intimately associated with this development. That pride is not only because this development plays one of the most important parts in this country's critically important aviation gasoline program but also because just as soon as the pressure of war is eased we see clearly ahead of us wide ranges of peacetime applications which may

have very real importance to everyone, whether or not they are involved in technical problems. For this reason it is my wish to speak about some of the ways in which research and development have been utilized to bring into being this great new unit.

This development was not worked out in a matter of days, weeks, months, or even a few years simply by dint of long hours spent over drafting boards or layouts in pipefitters' or boilermakers' shops. Nor, is this unit the brain child of a single inventor, since under today's conditions any such development calls for the unremitting teamwork of a large and diverse organization of hundreds of men and women working intelligently to the end that all necessary details are brought to a satisfactory conclusion on time. The genesis of this giant actually came about years ago as a series of individually small ideas, the possibilities of which were only partially recognized at that time and the techniques for which were experimented with in extremely small laboratory scale equipment. Had those working at these jobs had any idea of the long, hard road that lay ahead of them, I should not have been surprised had they become so overawed and so discouraged as to make their ultimate achievement impossible.

EXCEPT for a few changes and omissions, this article is the address delivered before the Maryland Academy of Sciences, November 30, 1943, the day previous to the dedication of the new units for making 100-octane aviation gasoline in the Baltimore plant of Standard Oil Company of New Jersey.

The theme of the program was "Petroleum in War and in Peace." Other speakers were Ralph W. Gallagher, president of Standard Oil Company (New Jersey), Chester F. Smith, president of Standard Oil Company of New Jersey, and Dr. Per K. Frolich, director of Esso Laboratories, chemical division.

In the picture above are, left to right: Dr. Christian Karrer, president, Maryland Academy of Sciences; Dr. Per K. Frolich, director Esso laboratories, Standard Oil Development Company; Robert P. Russell, vice president, Standard Oil Development Company; Chester W. Smith, president, Standard Oil Company of New Jersey; Ralph W. Gallagher, president, Standard Oil Company (New Jersey).

More and Better

More than 10 years ago it was recognized that some day it would be necessary to produce more gasoline from crude oil than could be produced even by thermal cracking. It was also clear that in addition to increasing the amount of gasoline it also would be necessary to improve it. Petroleum chemists naturally turned to the use of catalysts for bringing about both these things. (What is a catalyst?) The first catalytic process put into commercial operation was oil hydrogenation. Our company pioneered in the application of this hydrogenation process and it reached large-scale operation beginning in the early 1930's.

In this operation, we formed these catalysts into small pills for better contact. In the intervening years we have produced and used over 7,000,000,000 pills of catalyst for this operation. To give you some idea of its magnitude, I might point out that if these catalyst pills had been produced at the rate of one each second, it would take 222 years to make them.

The hydrogenation process, although of commercial application and although it has been a minor mainstay in producing aviation gasolines for United Nations' planes, was deficient in two respects. First, the plants required tremendous amounts of steel and equipment which could not be spared in the critical days of preparation and early prosecution of World War II. Second, the gasoline produced, although of high quality did not reach the perfection desired by petroleum technologists and by the builders and users of today's high-power aviation engines.

As a result, work was started a number of years ago to develop a catalytic-cracking process which would use less construction materials than hydrogenation and use a catalyst to increase the amount and improve the quality of the products made.

The aim of any catalytic-cracking operation is two-fold. First, it must increase the amount of gasoline made from crude by converting the heavier crude oil fractions of the type of kerosine and fuel oil into gasoline. Second, it must yield a gasoline of extremely high octane rating. The octane rating is an indication of the power that gasoline will give in an engine designed to make best and full use of it. Catalytically-cracked gasoline being of such higher octane rating does give greater power so that in the long run less of it will be needed, or in other words, a given amount of it will go further.

That cracking could be brought about by heating oil fractions in the presence of a catalyst had been known for a long time. There is no special difficulty in carrying out catalytic cracking on a small scale. However, as carried out in the laboratory, or in a plant for that matter, using pills or lumps of catalyst many practical difficulties are encountered. These difficulties, although not insurmountable, resulted in an operation which in many ways appeared undesirable. The development of a continuous process, although it presented engineering problems of considerable magnitude and complexity, seemed desirable.

Let us return now to the beginnings of the fluid catalyst process and sketch the stages through which it progressed.

Our first laboratory tests to insure that the catalytic cracking would be feasible with the oil stocks that are normally available were started scarcely half a dozen years ago. These tests, using catalyst pills or lumps

(since this was the form to which we had become accustomed in our work on hydrogenation), were carried out literally on a half-pint scale. A number of half-pint units were set up consisting of catalyst containers through which oil vapors could be passed and from which the cracked gasoline could be withdrawn. Hundreds of catalysts and dozens of oil stocks were tested with results so favorable that it appeared desirable to step up the scale of operation and to begin thinking about how to overcome the difficulties inherent in this stationary-catalyst-bed type of operation.

Early Progress

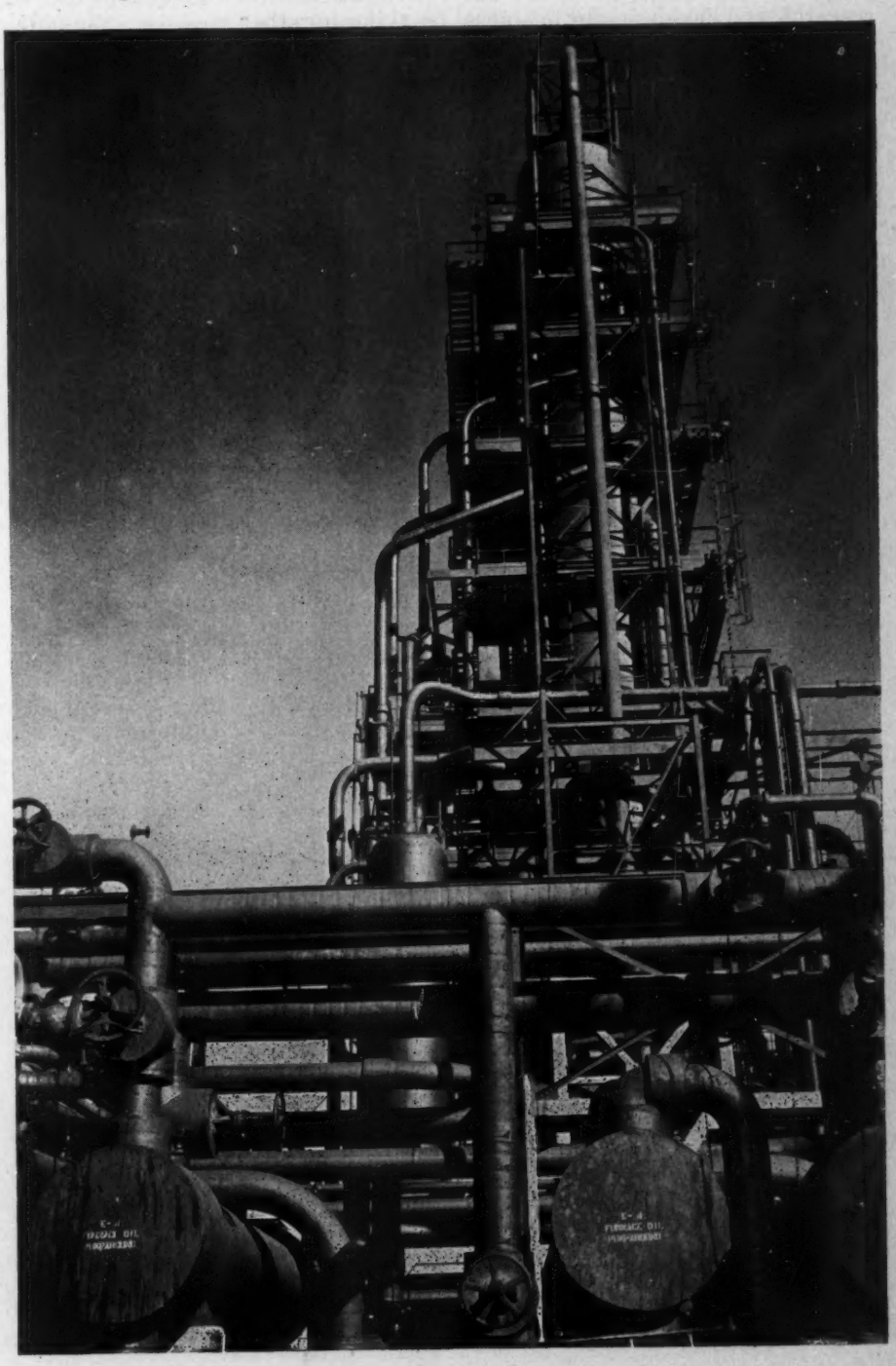
In these laboratory units it was found that catalyst pills or lumps would lose their activity as a result of coke being deposited on them. It was necessary to regenerate the activity of the catalyst frequently by burning off the coke with air. Although we knew that these difficulties would carry over into a larger unit the results certainly were worthwhile enough for us to build a 100-barrel pilot plant which contained three catalyst chambers. We needed three chambers, because while one of these chambers was cracking oil vapors, another one was ready to take up the load when the catalyst in the first chamber had lost its activity and the third chamber was in process of regeneration—thus the cracking operation itself could be continuous, although no one chamber was in continuous cracking service. Work on this rather large-scale pilot plant was carried far enough to insure that the operation was practical, that all necessary engineering factors were established, and design of a large plant of this type was begun and carried reasonably close to completion. We called this a "fixed-bed" type of plant because the catalyst remained stationary.

At this stage the size of the organization involved had grown from its initial few technical men to a very large team of more than 100 chemists, chemical engineers, and mechanical engineers who worked together with several hundred operators, analysts, and mechanics to keep a large number of pilot units in operation and to see that all the data collected were analyzed continuously and intelligently so that no time might be lost in arriving at a final workable plant design.

Just about the time that designs of our large fixed-bed commercial catalytic-cracking plant were approaching completion, we decided that in order to miss no bets, a major part of this large organization should work on various alternative techniques which offered the promise of being better than the fixed-catalyst-bed type of plant. Experiments with these different methods again were begun on a very small scale, some of the tests being carried out at our laboratories in New Jersey and other tests in laboratories in Louisiana. Among the different methods tried it soon became apparent that the use of powdered catalyst not only would make plants easier to build and operate but also brought about improvements both in the amount and quality of gasoline produced.

Turn to Powder

The laboratory tests with powdered catalyst were soon being scrutinized by all the chemists and engineers involved and shortly there was built a second 100-barrel pilot plant using powdered catalyst. In its operation catalyst from a hopper was forced by a screw conveyor such as is used in cement and other industries, into a vaporized oil stream and the mix-



Atmospheric crude pipe still

ture of catalyst and oil vapor was sent through a heated coil where the cracking took place. Again, after several months of intensive effort, the engineering details of the process were worked out quite thoroughly on this pilot plant and plans for a 20,000-barrel commercial plant began to go onto the drafting boards. Mind you, at this time, our catalyst-cracking work already had added up to the continued endeavor over at least a two-year period of probably 400 individuals, about a third of whom were chemists, chemical engineers, and mechanical engineers. In addition to our operating costs we had spent nearly a million dollars on the construction of our many pilot plants.

Then Fluid Flow

Just as the construction of this 20,000-barrel unit was about to begin there came one of those periods which gladden the heart of any research and development group and which make bearable the lives of people like myself, who spend our entire time in the research and development business. By tying together work on powdered catalyst being carried out at all the various experimental locations suddenly it became clear that if the proper amount of gas (either oil vapors, or air, or steam), were mixed with the catalyst, the catalyst became fluid and could be handled much like any other fluid such as water or oil. Further it became evident that this fluid composed of catalyst and vapor could be made heavier or lighter as desired simply by changing the amount of vapor added to the catalyst and by controlling the speed at which the new fluid moved through vessels or pipes. This technique of changing the density of the fluid could be used through a system of standpipes to generate any desired pressure at any particular point in the system and by proper manipulation could bring about circulation of catalyst through the unit without the necessity for any moving parts; thus no moving conveyors were needed in the system with the result that the troublesome screw features employed in the previous design could be done away with.

Here was a really revolutionary idea, and here again even this new twist to what was already a major development could not be attributed to any one man or even to any small group of individuals. It was the result once more of teamwork, of many ideas from many people with all these ideas brought together, assembled, considered, finally to emerge as a consolidated unit. It was clearly recognized at once that by the time these new principles were put into operation, still further simplification, still further ease of operation, and in all probability still further improvement in the yields to be obtained and the quality of the gasoline made, were bound to result.

Again, the 100-barrel pilot plant was completely rebuilt to put these new principles into effect, and the general simplicity of the operating scheme is that oil is pumped into the unit, is transformed into vapors in a heating coil and meets with a stream of catalyst coming out of a regenerated catalyst hopper. The oil vapors surround the individual particles of powdered catalyst creating a fluid mass which flows like any other fluid through a pipe system into a reactor. Here the cracking reaction takes place and the mixture of cracked products containing the gasoline along with the catalyst, which now is covered with coke, is separated in dust-separating equipment with the cracked materials going overhead to be condensed and separated into their valued components. The hot catalyst now covered with coke falls into a hopper from which it falls through a standpipe and mixes with a stream of air and passes on over into a regenerator where the coke is burned off the catalyst, leaving the catalyst fully regenerated. Catalyst and flue gases are separated from each other in a dust-recovery system and the hot regenerated catalyst falls into a catalyst hopper from which it can start again into the cracking section. After a relatively short period of operation of the pilot plant, the engineering factors were clearly established and it was possible to settle upon the designs of the first large unit.

How It Works

In the first of these units oil feed passes through vaporizing furnaces, the oil vapor meets a stream of hot regenerated catalyst and the resulting fluid mixture passes into the reactor where the cracking reaction takes place. The mixture of cracked vapors and spent catalyst passes into the dust-recovery equipment which separates the catalyst, and the oil vapors go overhead into a fractionating system in which the valuable components are separated into individual streams. The spent, coked catalyst passes down through a standpipe where it meets with the regeneration air and passes into a regenerator where the coke is burned off. The flue gases pass overhead through dust recovery equipment and after a final cleansing operation go out the stack. Some of the catalyst in the regenerator is recirculated around and around through heat exchangers or waste heat boilers so that part of the heat evolved in the regeneration step is utilized in generating steam.

At this stage there had been more than 5,000,000 man-hours of research, development and engineering endeavor packed into creating the fluid-catalyst process. Then came the job of designing and constructing the individual units such as the Baltimore giant. The extent of engineering work which must be added to the already impressive total of development hours to design such a unit, can be judged from the fact that about 125,000 man-hours of engineering work were required for this unit alone. This engineering work itself cost about $300,000. This again is on top of the tremendous sums spent in the research and development program which I have tried to sketch for you.

Refinery equipment seldom deserves special notice. There are 25 miles of pipe in the Baltimore catalytic unit alone, not counting other sections of the expansion program. One section of pipe is nine feet in diameter. It is enough of a job to install such tremendous piping but arrangements are also required to permit expansion of over 14 inches in length between room temperature and the temperature at which this pipe must operate.

The unit itself in operation is extremely quiet and to the casual observer there is no indication of the job being done within the walls. A boxcar full of catalyst circulates through these lines each two minutes and yet there is not a moving part within the unit itself. The catalyst flowing through the unit each day has a surface as large as the entire ground area of these United States. Yet, in spite of these tremendous amounts of catalyst circulated, less than one-fourth pound of catalyst is lost per barrel of oil fed.

One of Many

Large as is the cracking plant and great as is the volume of gasoline produced, many more plants are required to satiate the ravenous appetite of the war machine. Aviation gasoline of 100-octane rating is needed not only by the bombers and fighter planes, but also by transport planes that play an equally im-

portant part in the war strategy. The daily output of 100-octane gasoline from the Baltimore catalytic cracking unit combined with the alkylation unit is perhaps sufficient to fuel 200 bombers on a raid requiring the greater part of a day to reach and return from a target.

Since Pearl Harbor, in plants like the Baltimore unit and in their other aviation gasoline units, the refinery members of the Standard Oil Company (New Jersey) group have produced enough 100-octane gasoline to fuel a 1000-plane raid from England to Berlin and back every day for 1 year, 4 months and 15 days.

In addition to being a war plant the peacetime value of the fluid catalytic cracking unit should be recognized. The unit may readily be converted to the production of high octane motor gasoline in slightly greater volume than its aviation gasoline capacity. In addition to motor gasoline it will simultaneously produce fuel oil of the type used for heating private homes. When producing motor fuel to capacity it is estimated that enough fuel oil will be produced in a day to supply 100 average homes for a full year. It should not, therefore, by any means be concluded that the catalytic cracking plants are simply wartime projects to be scrapped at the termination of the war. These revolutionary new chemical engineering principles are destined also to find widespread application in other industries.

The fluid catalyst process has grown in a remarkably short time from a laboratory scale through a 100-barrel pilot plant to the giant of today. From the first commercial unit, over 100 times larger than the previous pilot unit, each succeeding plant has been built on a large scale. In spite of the growth of the units themselves the development has been marked by continuous simplification of the process. The mammoth units of today are almost automatic in operation and can be controlled by a handful of men. The process can be applied to the production of a variety of products and its simplicity and flexibility make it certain that the process presents a new tool that can be used with equal effectiveness in war and in peace.

I cannot stress too strongly that this major research, development, and engineering achievement has resulted from the unswerving loyal effort of a very large, very competent group of men and women. I am proud to be a member of the organization that has brought this revolutionary technique into practical application. It is the kind of achievement that is possible only under our American system and only when large groups of researchers, development men, and engineers understand the problems which must be solved and go to work and find solutions for them, and only when these successful research, development and engineering achievements are recognized and applied on a large scale by large industrial enterprises.

Control board at Baltimore

The Electron Tube—Genie, Gremlin, or Jeep?

W. D. COCKRELL, Engineer,
Electronics Section, Industrial Control Division, General Electric Company

THE average industrial engineer, unfamiliar with electronics, who glances through almost any magazine today, technical or popular, is apt to be overawed by the promises of electronic things to come. It is quite likely that his first impression will be that the electron tube is nothing short of a genie straight out of the Arabian Nights—a superhuman spirit of fantastic complexity and far too elusive for the average mortal to comprehend.

Or he may take the opposite viewpoint. These odd-looking electron tubes must fit into a class with the gremlins, mischievous little sprites, capable of much good, but more evil, and definitely to be shunned for as long a period as possible.

But on closer acquaintance, this electron "monster" loses most of its frightfulness, and turns out to be a friendly little jeep, rugged and reliable, capable of taking a terrific beating with minimum attention, while doing a man-size job.

Like the jeep, the electron tube can do its job 100 percent, but it cannot win the war unless the rest of the army pitches in to do its share. The rest of the "army" consists of the infantry of rheostats, transformers, and capacitors; the artillery of motors, generators, and amplidynes—all old friends, but perhaps not quite so quickly recognized under the speeded-up operations of this new mechanized warfare.

So let's all be good sports and not be too quick to condemn this electron "jeep" if the whole show does not come off as scheduled. Perhaps the break occurred at an entirely different part of the front. Did you ever shoot trouble for an hour and then find a blown fuse? That has happened on electronic panels, also.

What Are Electron Tubes, Anyway?

Are tubes hard to understand? Anyone who understands the use of the simplest copper-oxide rectifier, the rheostat, and the direct-current voltmeter, can become a tube expert after one easy lesson—well, anyway, he will know as much about an electron tube and how it functions in an industrial circuit, as many of us need to know.

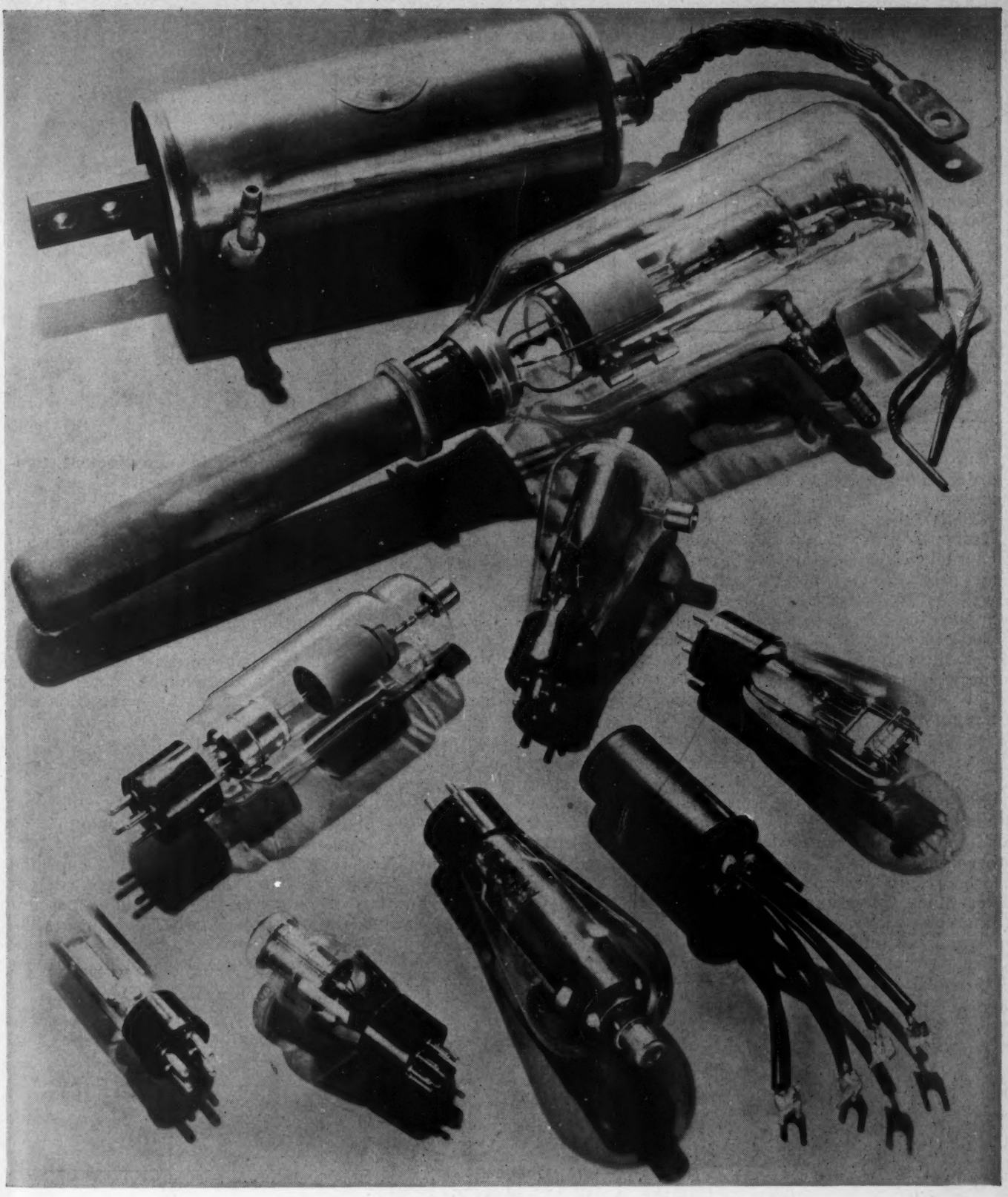
In the first place, every true electron tube is a rectifier—composed of at least two elements or electrodes enclosed in a vacuum envelope made either of glass or of metal. One of the two principal elements of each tube is called a "cathode." The cathode is made of special materials, and is heated, usually by a small electric heater, to release electrons—those fundamental particles of negative electric current.

In high-school physics we learned that anything charged positively attracts a negative charge. Then, in the next lesson, we learned that if the charge is negative, other negative charges are repelled. Thus, if we connect the other principal tube element, called the "anode," to a power source so that it is positive with respect to the cathode, the anode will attract the electrons from the cathode. But if conditions are reversed, and the cathode is positive and the anode negative, no electron flow will take place, because the anode is so made that it will prevent the loss of electrons. Thus, we get the one-way valve action of rectification; the electron flow (or the negative current flow, if you like to think of the normal current flowing from positive to negative) can move in but one direction through the tube—namely, from cathode to anode.

But that is not all. In these days of commando tactics, we are taught that it is most effective to kick a guy when he is off balance, or sock him when he is not looking. In a similar manner, if we can catch the current passing from cathode to anode in its simplest state, as a stream of electrons, we can control it with the greatest of ease. For instance, the electrons in an ampere-second of current weigh about a billionth of an ounce, something a lot easier to push around with a small control power than even the smallest and lightest switch or contactor. The control element added to the electron tube for this purpose is called a "grid," which is usually a spiral or grate of fine wires placed between the cathode and the anode. If the grid is held at a negative potential, with respect to the cathode, it tends to repel the electrons passing by it on their way to the anode, thus cutting down the flow of current, or possibly preventing it altogether. So long as the grid is negative, it pushes the negative electrons away, and thus collects no electrons to itself. No electrons means no current, and no current—even with a large impressed voltage—means no power. And to be able to control current without the use of power is a neat job.

Of course, if we make the grid positive, it will assist the flow of electrons to the anode and a larger current will flow, but only at the expense of some electron current to the grid. With the grid negative we can have control power for next to nothing.

The electron tubes that are used in industry may



Tubes used in industrial electronics equipment. Included are the ignitron, pliotron, kenotron, thyratron, phanotron and phototube.

be divided roughly into three groups: phototubes, high-vacuum tubes, and gas-filled tubes.

Phototubes

A phototube is a simple two-element rectifier in an evacuated glass bulb. The cathode is not heated to release the electrons, but is made of material which releases or "emits" electrons as light strikes it. These electrons can then be attracted as a small negative electric current to the positive anode. The number of electrons which should be kicked out of the cathode material when light strikes a small cathode would not be very large. We are lucky to get a millionth of an ampere, in most cases; and under certain conditions, the current is much less. In fact, the output is so small that in order to make use of it, we must boost

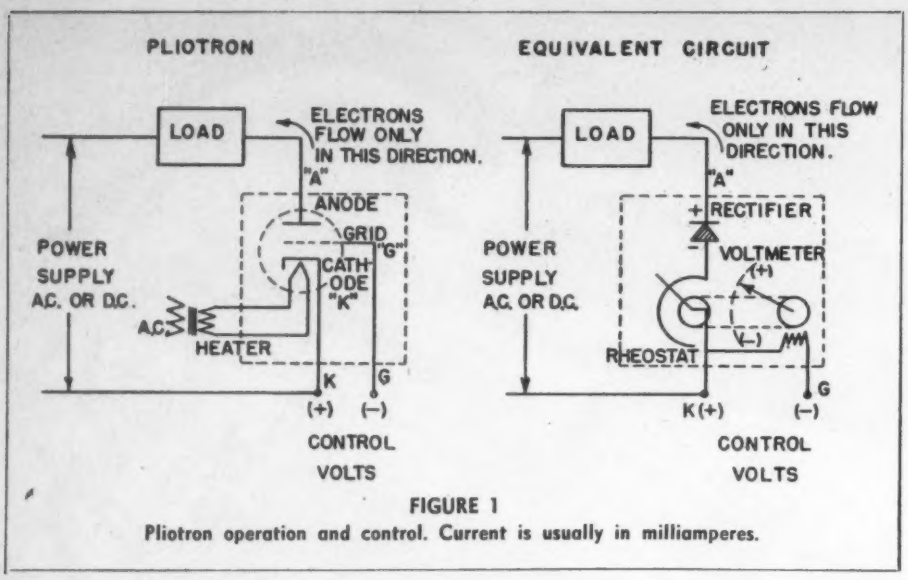


FIGURE 1

Pliotron operation and control. Current is usually in milliamperes.

it up or amplify it with a pliotron or thyratron, in order to operate even the smallest practical relay or motor.

Phototubes are the "electric eyes" of industry. Responding to a shadow or a flash of light, they may be used to count people, food, freshly painted articles, and other things which it is not desirable to touch, as well as to perform many other simple switching applications. In more advanced equipments, they can check or compare colors, read high temperatures, and control very rapid and accurate movements through the weightless and wearless light beams. The potential uses of the phototube are limited only by man's imagination.

High-Vacuum Tubes

Vacuum tubes which are simple rectifiers, and which have but two principal elements—the electron-emitting cathode and the collecting anode—are called kenotrons, or "diodes" ("di," indicating "two"). If we add one grid for the control of the electron stream, it becomes a "triode." All high-vacuum tubes with one or more grids are called pliotrons, or simply, amplifier tubes. Sometimes they are referred to by their function, such as transmitters, oscillators, or converters. If more grids are added in the electron stream to control the flow, as series valves in a pipe, the tubes may be called tetrodes (four-element, two-grid), pentodes (five-element, three-grid), etc. The typical vacuum tube is a low-current device which has a comparatively high voltage drop within the tube, yet it is capable of extremely fast and continuous control of the current with minimum grid power.

The pliotron is the familiar tube in radio receiving sets. Its role of amplifying a small signal or supplying a small output power is just as useful in industrial devices. Because of its characteristic of continuous control at extremely high frequencies, in the larger sizes it is used to supply the many kilowatts of power required for large broadcasting stations, or for induction and dielectric heating.

Gas-Filled Tubes

Gas-filled tubes, if used as rectifiers only, are called phanotrons; if they contain control elements, they are called thyratrons or ignitrons.

A thyratron tube has a hot cathode to emit the necessary electrons, and a grid to prevent current flow, when desired. However, it also contains mercury vapor, obtained from a drop or two of mercury in the tube, or it may contain inert gas, such as argon or xenon at low pressure. The gas or vapor helps to cut

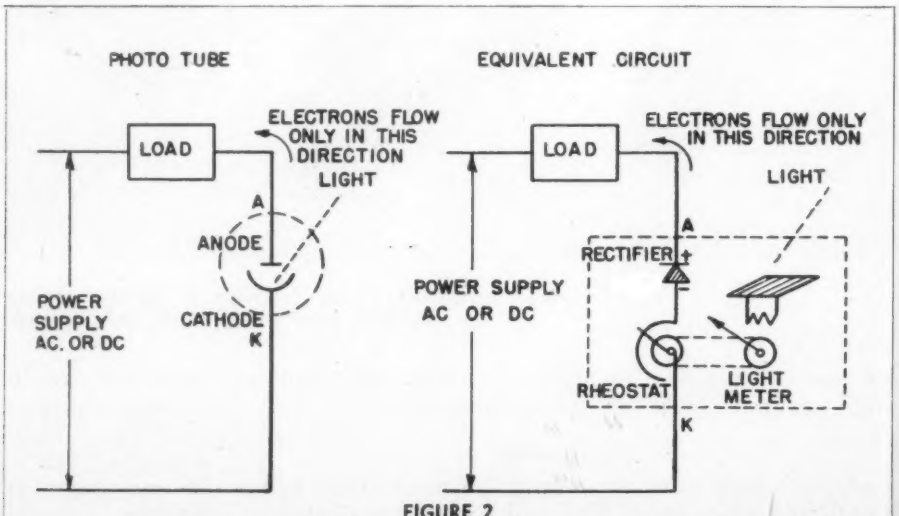


FIGURE 2

Phototube operation and control. Light controls a flow of microamperes.

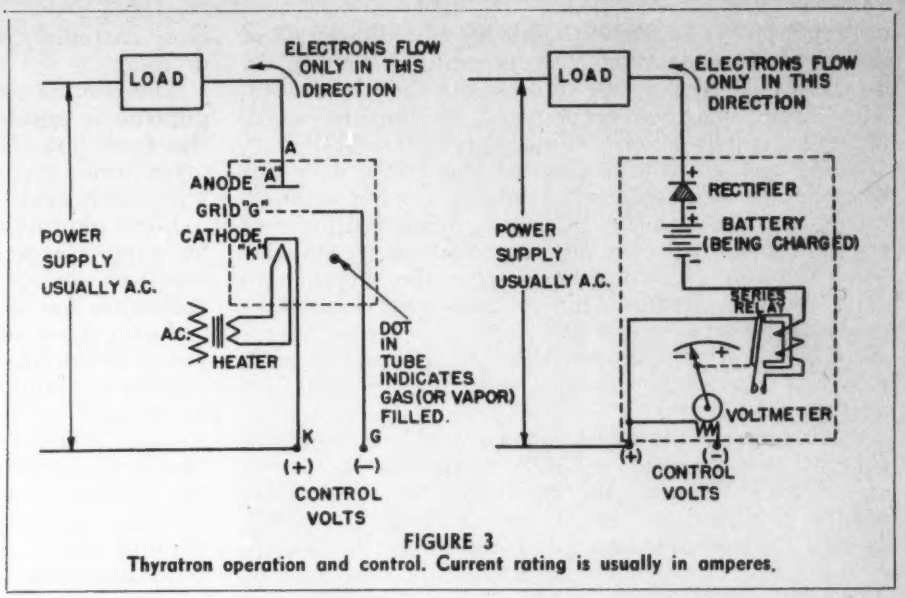


FIGURE 3

Thyratron operation and control. Current rating is usually in amperes.

down the high internal voltage drop found in the pliotron. A constant voltage drop of about 15 volts is held for any value of current within the ability of the cathode to supply electrons. (This is done by a process called ionization.)

Because of this low drop, a thyratron of a particular size can be rated for a continuous current of 10 to 20 times that of a pliotron of the same physical size. Thyratron current ratings run into amperes; most of the pliotrons with which we deal will carry continuously only a few milliamperes.

But gas filling does have a few drawbacks. For instance, the maximum voltage of the controlled circuit is limited, but it is still well above the usual industrial control voltage range. Of more importance to us is the fact that the gas prevents the grid from controlling the current after the flow has once begun. In other words, a negative grid will prevent the flow of current as the anode is made positive; but once it has permitted the electron arc to start, it is powerless to stop it. The current can then stop only as the anode power is removed, or, in any a-c circuit, during the a-c voltage negative cycle. Even then, the deionization time required to regain control may be approximately a millisecond; therefore, thyratrons do not operate at frequencies much greater than the commercial power frequencies.

The thyratron is the handy-man of the industrial tubes. It controls motors, energizes magnetic contactors, and supplies small amounts of heat whenever accurate control or high-speed operations are required. Operating indirectly, by controlling generator fields or saturable reactors, it can control large amounts of power—many hundred horsepower or many kilowatts—for heat or lighting.

The ignitron tube is similar to the thyratron in that it is a gas-filled tube, but it differs in that its cathode is not heated to free the electrons. Instead, its cathode is a pool of mercury and its electron-emitting energy is derived from the arc stream itself. This is a cumulative action—the larger the current the more electrons are made available. Thus, the instantaneous current capacity of the ignitron is limited only by the size of the elements and the leads

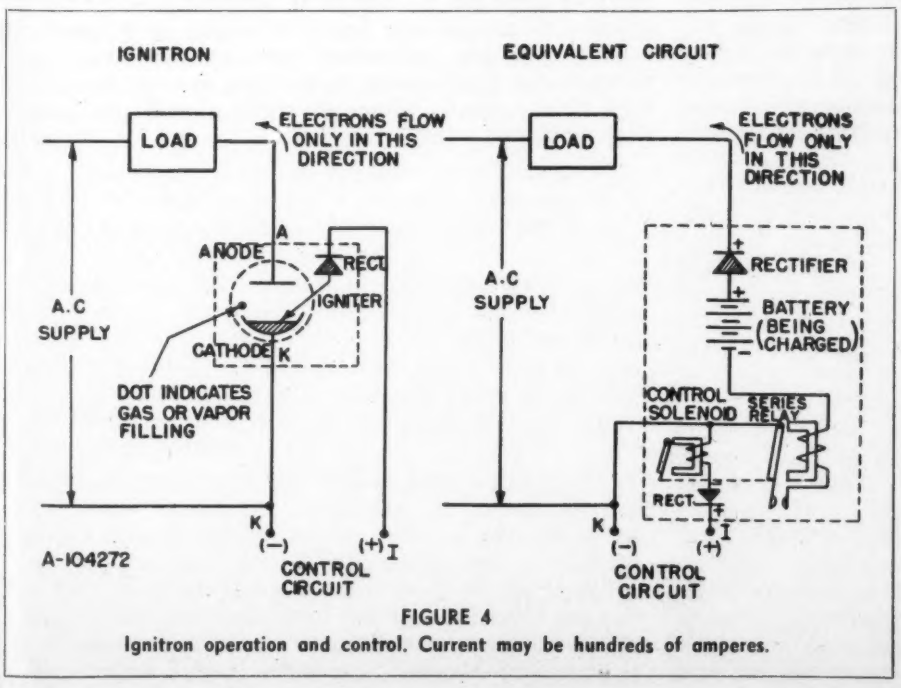


FIGURE 4

Ignitron operation and control. Current may be hundreds of amperes.

to carry the heavy current. This may be thousands of amperes. The continuous current rating is determined by the ability of the tube to dissipate the heat losses. The larger sizes of ignitrons have built-in water jackets through which cooling water is circulated.

Since the ignitron, unlike the thyratron, does not have electrons immediately available at a hot cathode, its control element, the "igniter"—a pointed piece of crystal dipping into the mercury pool—must actually "blast" a few electrons loose from the mercury to start the arc stream. This requires real power; as much as 40 amperes at 200 volts, for a few microseconds. So it can be seen why the ignitron is most practical for high currents and large power requirements.

Ignitrons are the heavy artillery of the industrial tubes. They are called upon to control the thousands of amperes required for resistance welding. They rectify and control the large amounts of power needed for the manufacture of aluminum, in electrochemical processes, and for steel-mill and factory direct-current shop voltages.

To sum up briefly, the phototube, using the energy of light to release electrons from its cathode, has so small an output in microamperes that a pliotron or thyratron must be used to amplify it to a useful value. The output of the pliotron (milliamperes) is sufficient to operate small relays, or to control a thyratron. Thyratrons, in turn, control amperes to operate large contactors, or motors in the usual control sizes from fractional horsepower up to 5 horsepower or more, or to control ignitrons. Ignitrons can handle hundreds of amperes, but require a reasonable amount of control power for operation.

How the Tubes Work

We said before that anyone who can understand a rectifier, a rheostat, and a voltmeter can understand tubes.

Take any kind of rectifier—copper-oxide or selenium—anything that will pass current in one direction and stop it in the other. Connect a rheostat in series and drive it by a voltmeter element, the positive terminal of which is connected to the negative terminal of the rheostat. Gear the rheostat to the voltmeter element in such a way that more negative voltage will cut in more resistance (see Figure 1). The rheostat is stepless, and goes to infinite resistance or open circuit at the high end. It is assumed that the voltmeter and rheostat can move extremely fast, 100,000,000 times per second; and the voltmeter is of extremely high resistance, perhaps a megohm or more.

This simple circuit can be used to replace a triode pliotron in any industrial circuit, and will do exactly the same job. If the tube is a tetrode or pentode, other series rheostat-voltmeter combinations may replace each grid.

For a phototube, simply replace the voltmeter with an exposure meter so that increased light on the sensitive surface will move the meter element to cut resistance out of the rheostat (see Figure 2).

As for the thyratron and ignitron, they are no more complicated. In series with the rectifier we place a battery of about 15 volts and so connect it that it will be charged by the current which the rectifier permits to pass. (This corresponds to the constant arc drop of the thyratron for all current values.) Finally, in the circuit is a series relay that is connected to "seal-in" or "lock-in," when the circuit is completed through its own single, normally open contact. The relay armature is moved, and this contact is closed mechanically by the action of the control voltmeter (just as the rheostat turned, in the description of the pliotron). The contact moves to close as the voltage becomes less negative (see Figure 3).

Once the contact has closed, however, the holding power of the series relay is so great that the small voltmeter torque is powerless to open it again until the current has stopped flowing.

The ignitron equivalent is about the same, except with larger power, and the size of everything becomes larger. In place of the voltmeter, we can use a small solenoid. A rectifier in series with the solenoid, to permit current to flow in but one direction, may not be necessary in our electromechanical picture, but it is necessary in the ignitron circuit to prevent injury to the igniter by reverse current (see Figure 4).

And that completes our one-lesson course on the industrial electron tube. We do admit that a few of the details about as essential as trouser cuffs and pocket flaps, have been omitted. But the fundamental facts are here, and we would like to prove it in this way. If you ever run into a wiring diagram that features one of these mysterious electron tubes that has been worrying you, do this: Before you lose any sleep or even get a vitamin B deficiency, just tear off a piece of an old war bond or ration book, paste it neatly over the offending tube symbol and draw thereon the appropriate equivalent symbol in a bold and steady hand. Then go right ahead and forget that electrons exist.

Spirit of The Times

(Reprinted from *Esso Oilways*, October, 1943)

Stripping Still

THE ancient Egyptians and Jews were perhaps the first to make alcoholic beverages. If this is true, it follows that they were the first peoples to drink ethyl alcohol—the type of alcohol which man commonly consumes.

This potable, and at the same time potent organic compound, was produced by the ancient Jews by fermenting honey, grapes, figs, dates and other fruits. The Egyptions were equally versed in the art of making a great variety of similar alcoholic beverages. They are said to have been the first to make beer some 4,000 years ago. Whiskey, gin, rum and similar drinks of high ethyl alcohol content, produced by fermentation of grains or molasses with subsequent distillation, came into existence later among other nations.

The ancients also made vinegar by allowing wine to stand exposed to the air. Vinegar is oxidized ethyl alcohol, or acetic acid. Today industrial acetic acid is made from synthetic alcohol.

Although the use of alcohol is firmly wrapped in the cobwebs of antiquity, the name of alcohol, oddly enough, was not bestowed upon it until 1500. Even Antoine Baumé (1728-1804) French chemist and inventor of a specific gravity scale, referred to alcohol as rectified spirits of wine. In England it is still commonly called spirits.

Ethyl alcohol itself, as well as beverages containing it, was taxed for centuries. It remained for England first to recognize the value of alcohol as an industrial chemical and to encourage and extend its use. The English government made it tax-free in 1855, but the law exempted the alcohol only after it was denatured or made in some way unfit to drink. In the United States, however, Congress waited until 1906 to pass a law which placed denatured ethyl alcohol on a tax-free basis.

Despite centuries of use, the composition of ethyl alcohol was not determined until 1808 when a French chemist proved it to be C_2H_5OH.

From Many Sources

Ethanol is the chemical name for ethyl alcohol. It can be made by fermentation of any product containing starch or sugar. In fact, about three fourths of the so-called commercial alcohol in the United States in normal times is made by fermenting blackstrap (lowest grade) molasses, which contains up to 60 percent sugar. Chemists say they can make alcohol also from almost any hydrocarbon compound plus water.

There are many types of alcohols besides ethyl. There is methanol (methyl alcohol) commonly called wood alcohol (CH_3OH), propyl and isopropyl alcohols (C_3HOH), and others such as butyl, amyl, hexyl and dozens more. All are combinations of a hydrocarbon radical and that indispensable radical OH. Technically, phenol (carbolic acid) is an alcohol; so is glycerine.

To make whiskey, the whiskey experts may also color and flavor the ethyl alcohol which they produce from grains by aging it in wooden barrels. Many a whiskey distillery is now producing ethyl alcohol from grains for the war program and, more recently, from specially milled flour. The fermented liquor from grains or molasses, which contains about 10 percent crude ethyl alcohol, is concentrated by fractionation. During fermentation as much carbon dioxide by weight is produced as alcohol. The carbon dioxide may be compressed into commercial "dry ice" or the

gas may be liquefied and sold to makers of carbonated drinks.

The Standard Alcohol Company has long been a producer and marketer of isopropyl and secondary butyl alcohols. The company was the first to make isopropyl alcohol commercially from petroleum in 1920. This year—1943—it became the first petroleum refiner and the second company in America to manufacture ethyl alcohol from a refinery gas—ethylene. The alcohol plant is operated by the Standard Oil Company of Louisiana, Baton Rouge.

Total annual capacity of all ethyl alcohol plants in the United States using petroleum ethylene as the raw material amounts to something over 70,000,000 gallons of 190-192 proof. By comparison, the entire commercial alcohol industry which employs molasses as the raw material produces in an average normal year only about 100,000,000 wine gallons of 190-proof alcohol, the manufacturing of which requires about 250,000,000 gallons of blackstrap molasses as raw material. Today national ethanol production by all processes is over 500,000,000 gallons, five times the 1939 volume figure. Whiskey distillers now supply more than half of the current production.

Low Cost

In actual practice it takes around 2.5 gallons of molasses to produce one gallon of 190-proof ethyl alcohol. To make the same amount from grains requires about 0.4 bushel of the grain. The cost of molasses or grain alone is, at present, higher than the cost of the finished petroleum ethyl alcohol.

Fully half of the nation's ethyl alcohol goes today to a use which did not exist at all in this country before Pearl Harbor—the manufacture of butadiene. Now every reader of the daily papers may be aware that butadiene is an essential ingredient in Buna-S rubber upon which the government's rubber program is based. Enormous quantities of 160-proof or higher are consumed in the manufacture of smokeless powder. In this connection it is used as a dehydrating agent for nitrated cotton. Mixed with ethyl ether, the alcohol is used also as a solvent in smokeless-powder production.

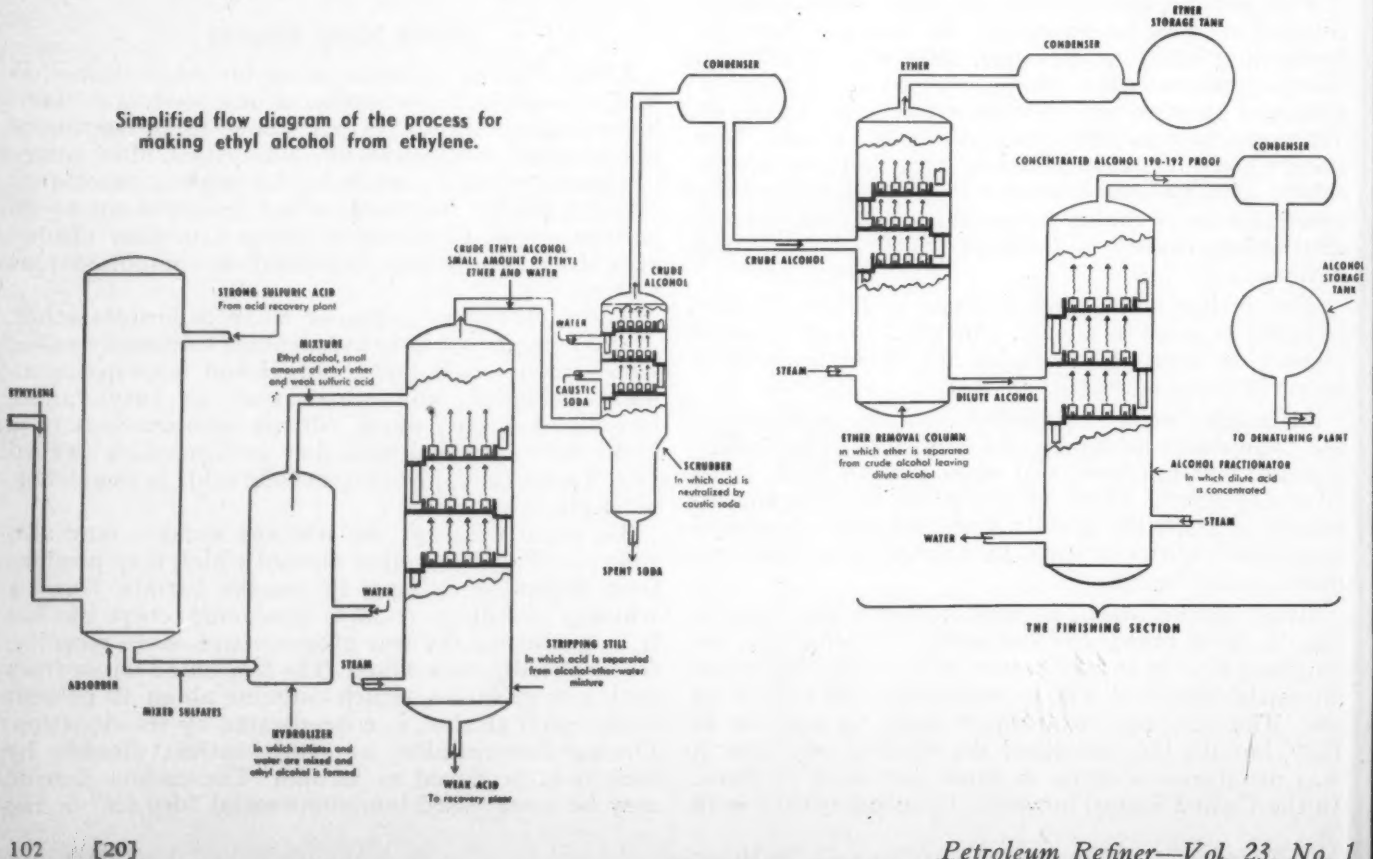
Large quantities of ethyl alcohol are used by makers of synthetic resins, such as cellulose acetate. In this process the alcohol is oxidized to acetic acid and the latter, in turn, is converted into acetic anhydride which is combined with cotton linters or wood pulp to form cellulose acetate.

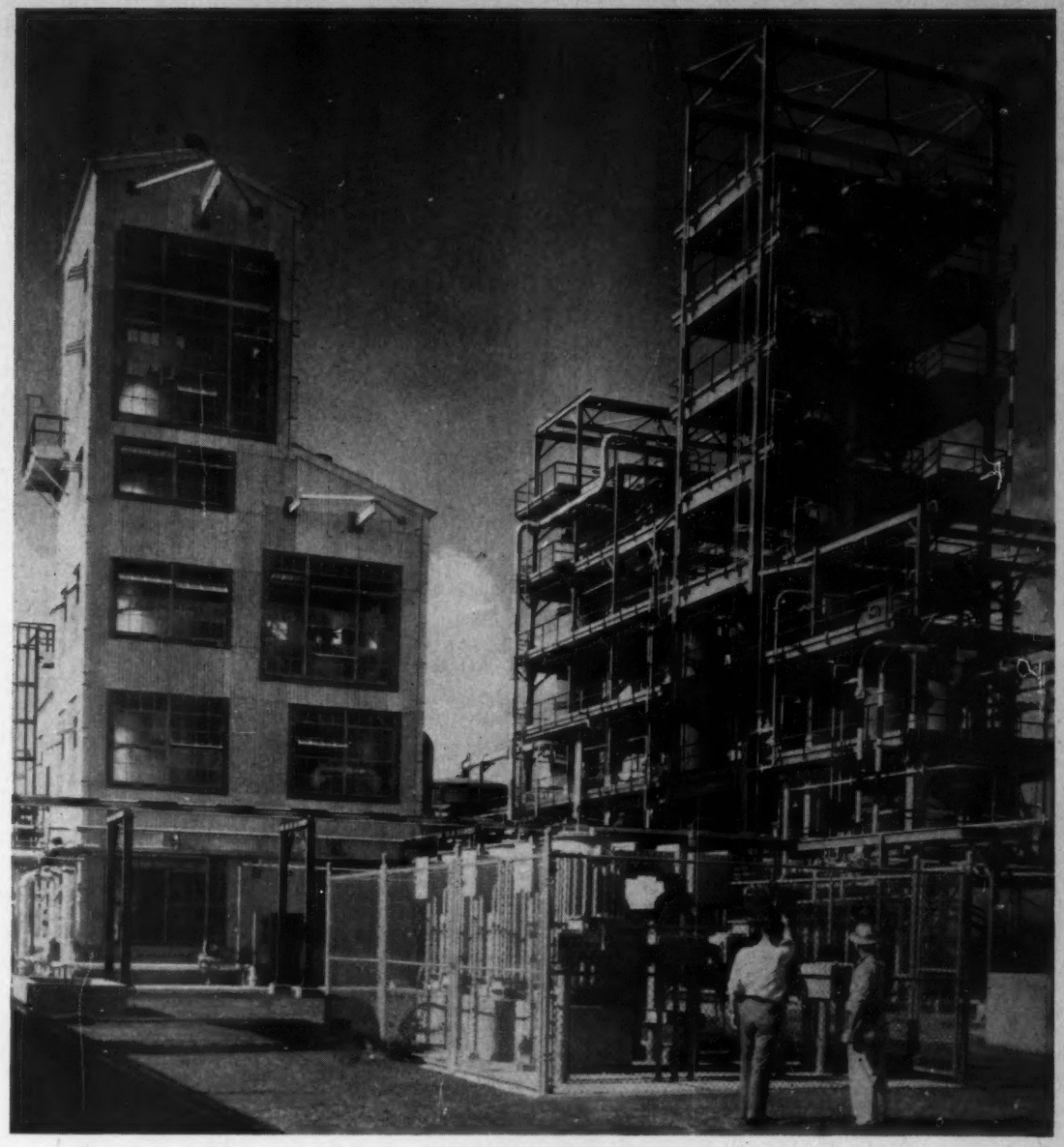
In normal times large quantities of ethyl alcohol are used as solvents in shellac, lacquer and varnish. Every housewife is familiar with other products in which ethyl alcohol is essential. In flavoring extracts, such as vanilla, it is employed as a solvent. All tinctures contain ethyl alcohol. It performs the same function in many perfumes, in liniments, sun-tan lotions and many other products. Coal tar dyes used in foods are dissolved in ethyl alcohol. Collodion and shampoos and other liquid soaps either contain ethyl alcohol or are made with it.

Before the introduction of isopropyl alcohol, rubbing alcohols were usually nothing more than denatured ethyl alcohol. Isopropyl alcohol is now used for this purpose. Patent medicines by the score contain ethyl alcohol. It is also used as a raw material in the manufacture of a long list of chemicals, the names of which begin with ethyl. There is ethyl acetate, formate, sulfate, oxalate and others already mentioned. A majority of our automobile anti-freeze solutions use ethyl alcohol as a base. The alcohol, or its gas of origin, ethylene, is used to make the tetra-ethyl lead used in Ethyl gasoline.

Up to 1935 ethyl alcohol was produced commercially only by fermentation of starches and sugars. Then one company got into commercial production on ethyl alcohol made directly by hydrating ethylene produced from oil. In 1935 Standard Alcohol Company started

Simplified flow diagram of the process for making ethyl alcohol from ethylene.


ETHER STORAGE TANK
CONDENSER
CONDENSER
ETHER
CONCENTRATED ALCOHOL 190-192 PROOF
CONDENSER
CRUDE ETHYL ALCOHOL SMALL AMOUNT OF ETHYL ETHER AND WATER
CRUDE ALCOHOL
CRUDE ALCOHOL
ALCOHOL STORAGE TANK
STRONG SULFURIC ACID From acid recovery plant
MIXTURE Ethyl alcohol, small amount of ethyl ether and weak sulfuric acid
WATER
CAUSTIC SODA
ETHYLENE
STEAM
DILUTE ALCOHOL
ETHER REMOVAL COLUMN in which ether is separated from crude alcohol leaving dilute alcohol
TO DENATURING PLANT
SCRUBBER In which acid is neutralized by caustic soda
ALCOHOL FRACTIONATOR In which dilute acid is concentrated
SPENT SODA
WATER
STEAM
WATER
STRIPPING STILL In which acid is separated from alcohol-ether-water mixture
ABSORBER
MIXED SULFATES
HYDROLIZER In which sulfates and water are mixed and ethyl alcohol is formed
WEAK ACID To recovery plant
THE FINISHING SECTION



Crude Alcohol is made in equipment at the right and finished in the building at the left.

to operate a pilot plant to perfect a process it had developed in the laboratory to produce ethyl alcohol from refinery ethylene. It is the gas which is often used to ripen fruits quickly after they have been shipped green. It is used in the production of styrene, which is also an ingredient in Buna-S synthetic rubber. Ethylene may be used to make novocaine, the local anesthetic, as well as mustard gas and other products.

Processing Methods

The story of ethyl alcohol from ethylene is not new to chemists. They know, for example, that around 1850 Faraday and the German chemist Hennel had reacted sulfuric acid on ethylene to produce ethyl alcohol. Other experimenters have produced ethyl alcohol by passing ethylene through water in the presence of a catalyst, thus effecting hydration of the ethylene.

But the commercial manufacture of ethyl alcohol from ethylene is not as easy as that. One manufacturer has tried chlorination of ethane (C_2H_5) which produces ethyl chloride. This is hydrated with caustic soda to make the needed alcohol and a by-product, sodium chloride. When acetylene is converted into acetaldehyde, and the latter is hydrogenated, the result is ethyl alcohol and a number of other products.

The average petroleum refinery employs mixtures of ethylene with other by-product gases as fuel for boilers. As a rule a refinery does not produce this gas except in low concentration in other gases, and to make it in quantity calls for adjustment in the usual refinery practices. This is quite important in the production of ethyl alcohol, because, if the proper amount of ethylene is not produced on schedule, neither can the alcohol plant operate on a definite time-table.

After several years of development, Standard Alcohol Company and Standard Oil Development Company designed a plant to produce ethyl alcohol from ethylene and a plant was erected adjacent to the Baton Rouge refinery of Standard Oil Company of Louisiana. A special cracking plant in this refinery was adjusted to supply the required amount of ethylene. Needless to say, the problem of securing proper materials to build the new type alcohol plant was quite difficult but, fortunately, not insurmountable.

When the plant started operations in March, 1943, it became the first petroleum refinery in the world to manufacture ethyl alcohol. Sprawled over nearly five acres and costing many millions of dollars, the plant from the beginning turned out an excellent quality of 190-192-proof ethyl alcohol every month. Although of equally good quality, it is sold at a price

far below that produced from grains, potatoes or molasses.

At the Baton Rouge plant the basis of the process is, of course, the hydration of the ethylene. To do that on a commercial scale requires an immense plant. The very rough flow diagram shown herewith omits many miles of piping, many vessels, pumps, compressors, boilers, control rooms and other equipment. The details of the process are, naturally, not disclosed.

The alcohol plant is roughly divided into three sections: the crude alcohol producing, the alcohol finishing and the denaturing and handling.

The ethylene from the refinery is cleaned and piped to the alcohol plant. It is pumped into an absorber. Within this absorber the ethylene is reacted upon by sulfuric acid. The liquid resulting from the action of the acid on the ethylene produces mixed monoethyl and diethyl sulfates.

By sending this mixture through another vessel into which water is fed, crude ethyl alcohol is formed but it is mixed with other products such as weak acid and ethyl ether. The ether is easier to remove later in the process because it is not soluble in water, while the alcohol and acid are soluble. A stripping still, somewhat like a fractionating tower, effects the separation of acid from the vaporized mixture of alcohol, ether and water. Steam is used in the stripping still because it evaporates the alcohol and ether and permits them to leave at the top with some water vapor. The acid is sent back for re-use in the absorber.

The next step is to remove any small amount of acid which may have been carried over with the alcohol-ether mixture at the top of the stripping still. A scrubber does that job with the aid of caustic soda and more water. The water-soda mixture drops to the bottom of the scrubber while the alcohol-ether mixture leaves the top in vaporized form and is passed to a condenser, thence to the finishing plant. Actually there is only a small amount of ether in this mixture, which is mostly crude alcohol and water. The first step in finishing is to remove the ether, which is done by introducing steam at the proper temperature. It vaporizes the ether which leaves at the top of the tower. When condensed it is ready for storage.

The crude alcohol, however, must be sent through a fractionator (another fractionating tower) to remove its water content. This vessel, which is said to be the largest still of its kind in the world, causes the alcohol to be evaporated out of the mixture while the water is condensed on a series of trays and falls to the bottom from which it is piped off and used again. The alcohol in vapor form condenses into 190-192-proof which is pumped to unfinished alcohol tanks, a point which forms the dividing line between the alcohol finishing section and the storage and handling facilities.

If, after testing in the laboratory, the alcohol in the unfinished tanks meets all specifications, it is pumped to one of two weighing tanks in the receiving room as finished alcohol. The alcohol is then weighed and transferred to one of two weighing tanks in the denaturing plant. A weighed amount of denaturant is added, the contents of the tank weighed, mixed, and transferred to alcohol storage tanks. The denaturant may be a product such as methanol, which when absorbed by the human system, produces blindness. Other denaturants also are used. While alcohol without denaturants is taxed by the government, denatured products are not.

The specially denatured alcohol is pumped to the loading rack for shipment in tank cars to consumers.

Although ethyl alcohol and products containing it are highly important to the nation, other alcohols must not be overlooked.

Methanol, for instance, is widely used as an industrial solvent, and as an anti-freeze. It is also widely used as the raw material for making formaldehyde.

Methanol is also produced to a small extent by destructive distillation of wood, which ends up as charcoal. There are other valuable products in this operation, such as acetic acid, for example. About 6,000,000 gallons of methanol per year are made in this way.

There are now two methods in use for producing methanol synthetically, resulting in a national production which has grown since the war started from 25,000,000 gallons to 75,000,000 gallons annually. These processes had their beginning in 1923. In one methanol process, methane is oxidized in the presence of a catalyst, while in the other carbon monoxide is reacted with hydrogen in the presence of a catalyst. This process employs the same equipment as is used to make synthetic ammonia.

Standard Alcohol Company has been a large producer of isopropyl alcohol ever since it originated the process for making it from propylene, produced during cracking of gasoil. Standard Alcohol Company has isopropyl alcohol plants at Bayway, New Jersey. During wartime this alcohol is used largely to make acetone, which is used as a solvent in the manufacture of synthetic resins and for many other applications. Isopropyl alcohol also is used as a deicing fluid on war planes, as a fuselage cleaner, in shock absorber fluid, to crystallize vitamins, as a lacquer thinner, as a solvent for plywood-impregnating solutions, and to make isopropyl acetate, a solvent for nitro-cellulose which is used in explosives and other products.

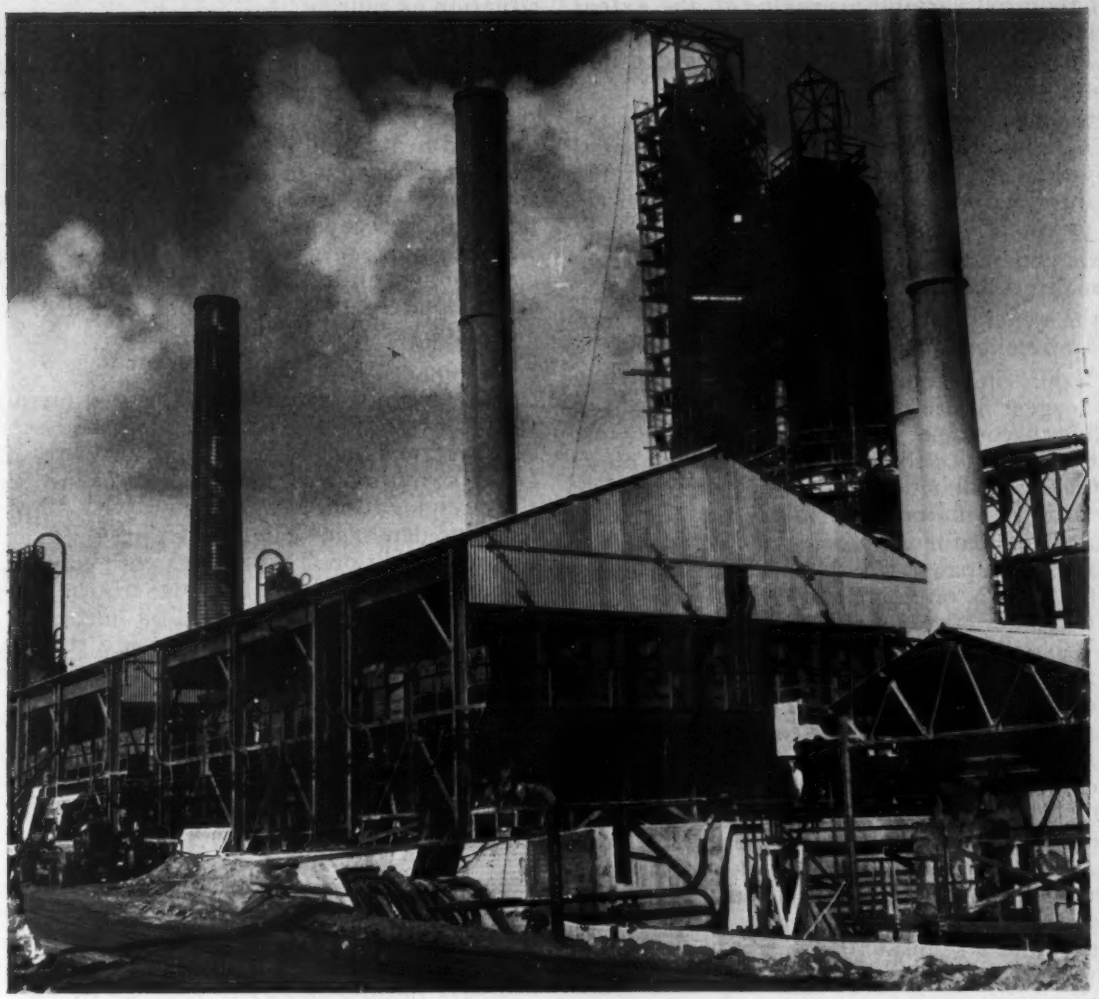
Secondary butyl alcohol, also made by Standard Alcohol Company, is manufactured from normal butylene, another gas produced during thermal and catalytic cracking of gasoil. In normal times it has a wide range of applications in the manufacture of synthetic rubbers and resins and as a solvent in many chemical processes. At present secondary butyl alcohol is used to make secondary butyl acetate and methyl ethyl ketone.

In the United States the word proof as applied to alcohol refers to its strength. Maximum strength, or pure alcohol, is designated as 200 proof. Thus, if an alcohol is 150 proof it means that it contains only three fourths pure alcohol. A mixture of 95 percent pure alcohol and 5 percent water is called 190-proof alcohol.

Distilled spirits are sold in containers labelled to indicate the proof of the alcohol contained in them. A 100-proof whiskey contains 50 percent pure alcohol. For beers and wine the actual pure alcohol content is indicated on the label.

Some users of alcohol products use the expression "proof gallon." This is a gallon of 50/50 alcohol-water mixture, or 100 proof. This is the unit on which a product is government-taxed and hence is often called a "tax gallon." Taxes of other strength alcohols are figured from the tax gallon as a base. A wine gallon, incidentally, means 231 cubic inches of alcohol of any proof.

In the new ethyl alcohol plant at Baton Rouge further evidence has been offered to demonstrate the versatility of petroleum.



Furnaces under construction in Union Oil Company plant.

Economics of Combustion

EDWIN L. DENNIS,
Chief Combustion Engineer, Coppus Engineering Corporation

WE HARDLY believe that anyone can accurately predict just how the return of peacetime operation will affect the end uses of various refinery gases and liquids.

We do believe, however, that decreasing supplies of fuel have forced refineries to change their former attitute toward "waste" products. Regardless of the ultimate or normal demand for synthetic rubber, the realization of the necessity of conservation of fuel, as well as of supplies of fuel, has forever changed the picture from that of ten years ago. Heretofore refiners thought that "waste" products would always be available in excess of fuel requirements for the processes of modern refining. Up until now, very little technical thought has been devoted to the economics of combustion; too little attention to selection of burners and furnace design.

AS AN introduction to this paper, presented December 10 before the technical group of Western Petroleum Refiners Association in Tulsa, the author dealt briefly with the crude-oil reserves of the United States and expressed the opinion that more raw material will be found. He paid this tribute to the industry:

"We do know that the producing part of the oil industry is not standing still but is keeping pace with the refiners and as a result more reserves will be discovered, more efficient recovery will be developed and other improvements made that will increase the 'dividend' or oil reserves."

Regardless of the advent of improved processes of catalytic cracking, thermal cracking and polymerization, hydrogenation or other complexes, the story of

oil refining remains one in which an amount of heat is required per barrel of oil refined. The "amount" of heat (fuel) required varying according to the extent of the refining process and/or the methods of refining practices. This "heat" or fuel required is divided into the following uses—

A. For the heating of oil, liquid or gases in the processes of refining pertaining to the chemical and/or physical changes in the composition of the crude and intermediate products of refining by direct heat from products of combustion.

B. For the generation of process steam as differentiated from direct heat as in A.

C. For the generation of steam for prime movers, pumps and miscellaneous purposes.

Although the "fuel required per barrel refined" may not be the largest figure on that all-important sheet, "Total refinery cost per barrel run," of the cost accountant, we advance the thought that in too many instances this figure has been taken for granted while it actually offers a major opportunity for the technologist to affect major economics at relatively low expense to his company. We believe that in many instances the return on funds expended to increase thermal efficiency of existing equipment, and incidentally capacities in a number of cases, is more attractive than any other. It is possible that the spotlight is and has been played on the very major plant enlargements as well as due to the fact that most men have been doing the work of two that this opportunity has been neglected. Upon the return to normalcy more attention to "plain Jane" can be anticipated.

In too many instances in oil refineries the utilities department, i.e., steam and electric generation, have been treated as the proverbial stepchild of the industry. Funds have not been made available for modernizing or improving existing equipment. Only when utilities are no longer able to supply the needs of production without consideration of good engineering practices, and with complete disregard of efficiency, are funds made available and then too often only with provisions for increased capacity without improvements of existing equipment. Unfortunately the power engineer is often made the "goat" by an unsympathetic operating department coupled with a Pontius Pilate attitude on the part of the technological department.

This is not, perhaps, a general indictment but within the past 12 months we have witnessed in three major oil refineries striking examples of this attitude towards the utilities department or boiler house. In each case there had been an accumulation of butane in excess of storage facilities resulting in an emergency condition where it became necessary to return the liquid to the fuel system. In each case the fuel system was inadequately designed to handle any quantity of liquid in the gas mains. Also each system was laid out so the first victim was the boiler house. That was not coincidence. Unfortunately in one refinery the dump was so great that the boiler house was not the sole sufferer. The liquid went past the boiler house washing pipe scale along the system and plugged every orifice in a large furnace fired with floor-type burners. It required several days of unscheduled shut-down of this unit, resulting in serious loss in throughput, to drill out the 10,000 orifices in this furnace. The results in the two other refineries were not as serious, but did cause a great deal of trouble and unnecessarily so. In each case the needless expense incurred would have more than paid for the complete cost of an adequate and properly designed fuel system that would have handled the situation as routine.

On the other hand we know a fourth refinery that has not treated the utilities as a stepchild. In this refinery the fuel system is designed so that the high Btu refinery gases as well as butane are passed through a closed heater and brought to elevated temperatures to assure a dry gas main. The heat required is secured from back-pressure or exhaust steam and is practically fully recovered in the gas. The cost of heating was negligible. As a result the mixed gases in this gas fuel system is always at an elevated temperature, approximately 130° F. average, and dry.

First Requirement

The foregoing examples were used merely to illustrate that the first prerequisite of good economics of combustion is an adequate and properly engineered fuel-distribution system in which is incorporated all the equipment necessary to cope with all of the problems incidental to delivery of the fuel to the furnace in good condition. This applies with equal importance to the liquid-fuel system as to the gaseous-fuel system. The efficiency of fuel-oil burners is probably even more sensitive to poor design than is the case with gas burners. No expense should be spared in assuring that oil under ample and steady pressure (relatively free from pulsation) and at proper temperature will be available at the furnace regardless of weather variables and/or change in fuel specifications. The steam for atomization should always be available at the furnace, free of condensation and at constant pressure in the supply main. The original cost of a properly designed fuel system is not much more than that of an improperly designed system. The ultimate cost of an improperly designed system over a period of years may well be one hundred fold that of a properly designed system, because its cost increases with each day of less efficient operation.

It is said, "A woman's work is never done." This applies equally well to plant engineers. Constant changes and additions which come by degrees may necessitate emergency fuel lines or disturb the general system so that a previously well-designed system may become inadequate. It is not a reflection on plant engineers that such cases remain unnoticed due to circumstances and that the effect of additions and changes is cumulative.

The fuel distribution system of any refinery deserves a carefully made annual or semi-annual survey, and a detailed report of recommended improvements. This report deserves prompt attention and action on the part of plant management.

In oil refineries there are generally fuels that have no commercial value. These are truly waste fuels unless used by the refinery. We speak of tank bottoms, acid sludges or any non-salable material containing combustible matter. This paper does not treat on these fuels but it should be stated that the correct end use of these should be in the boiler house, as is the general practice. The facilities for handling deserve just as much consideration as any other refinery facility.

A study of the economics of combustion of a refinery would be most incomplete if some attention were not paid to the greatest loss of generated heat "stack losses," or to that energy dissipated to the atmosphere in the products of combustion leaving the many stacks in every refinery. The yardstick of

economy needs be applied in any industry whenever changing conditions result in a different measure. Conservation of fuel within the oil industry is as important as it is at a central station power plant. This has been made more apparent within the past three years than ever before but a barrel of fuel saved at the refinery has just as much fuel value as one sold outside the industry.

With this homely observation it might be concluded that any investment in waste-heat-recovery equipment that would be economically sound for a central station would be so for an oil refinery. That, however, is not always true from a dollar-and-cents angle. The dollar value of a barrel of fuel, or its equivalent, at the refinery is less than its value outside of the industry. The outside user must add transportation and handling costs.

On the other hand, stack temperatures on many refinery furnaces are higher than those encountered by most other users of fuel. On many cracking units stack temperatures approach 1000° F. In such cases we believe an engineering analysis will demonstrate that the addition of recuperative equipment would be a sound investment. Air preheaters and auxiliary equipment require little maintenance and are trouble-free in operation. It is hardly possible to fix a point where addition of waste salvage equipment would be universally applicable in oil refineries as a sound investment. In this respect the thought is advanced that a point of beginning might be taken as any heater having a heat input of 50,000,000 Btu per hour and a stack temperature of 700° F. or above would be deserving of a careful study to determine the pay-off of recuperative equipment. With this starting point the various furnaces in a refinery could be classified into those on which recuperative equipment would be a sound investment and otherwise.

There is an opportunity for the manufacturers of waste-heat-recovery equipment to cooperate with the oil refiners in a complete investigation of the possibilities of affecting material fuel savings by the judicious application of recuperators on refinery heaters as well as boilers. It is to be hoped that post-war industry will be frugal and conservative but that funds will be made available for those needs to conserve, be it fuel or any other resource of our nation.

So far, we have dealt with the economics of combustion only to get the fuel to the furnace and to salvage, when practical, heat from the stack gases. There remains the economics of burner selection and furnace design to be given attention.

In the first place attention should be called to the error in nomenclature as refers to the word "burner." Webster defines the word: "burner—noun, 1. That which burns. 2, The part of a gas fixture, furnace, etc., where the flame is produced." A "burner" as commonly accepted certainly does not conform to the definition, because flame is not produced in the burner. Actually, a gas burner is a mixing device designed to mix the combustible with the necessary air to carry out combustion. The degree of perfection reached by the burner in mixing and proportioning the fuel and air to meet the needs of the application should determine burner selection.

This discussion will treat burners as mixers and proportioners of fuel and air and how their design affects the economics of combustion in oil refineries.

Bunsen stated, "An ideal gas burner is one with an infinite number of gas orifices interposed across the air stream." In his next statement he said, "This cannot be approached in practice because the space occupied by the gas conduits would soon occupy all available space." What Bunsen meant was an ideal gas burner would be one that would deliver a completely homogeneous mixture of correctly proportioned air and gas to a furnace. To what extent modern design has been able to approach Bunsen's ideal burner will be discussed subsequently.

It must be noted that on some applications the ideal burner described by Bunsen would not be desirable. Some furnaces or processes are so designed that slow or progressive combustion is paramount. In the oil industry, however, such applications are the exception rather than the rule.

Dr. W. Trinks, Professor of Mechanical Engineering at Carnegie Institute of Technology, in his book "Industrial Furnaces," summed up the problem of proper burner selection in one simple sentence, "Burner design, therefore, is mixed design."

There is no gas burner that can produce one single Btu more than any other burner in burning a fixed quantity of the same gas to the end products of carbon dioxide and water vapor. There can be, however, a vast difference in the Btu's that will be recovered or are recoverable from the products of combustion of a fixed quantity of the same gas on the same furnace when fired with different burners.

It is necessary to review some of the chemistry and physics of combustion as well as the mechanisms of heat transfer to show the importance of this statement.

It is generally accepted that combustion is a series of chemical reactions of progressive oxidation of a combustible material. These reactions liberate heat in amounts proportionate to the degree of oxidation carried out, the chemical analysis of the fuel and rate of fuel consumption. If sufficient oxygen is supplied to complete the reactions, the same amount of heat will be liberated in combustions of a fixed quantity of fuel regardless of the rate of combustion or the intermediate reactions that may or may not exist during the process of complete combustion.

The laws of conservation of energy and mass can not be avoided. "Energy can not be created or destroyed." "Matter can not be created or destroyed."

The rate at which combustion takes place in a furnace is affected by many factors. In practice those that are most important are the intimacy or degree of complete mixture of the fuel and air upon entering the combustion space and the temperature not only of the combustion space but also of the flame propagated. When a homogeneous mixture of gas and air that contains exactly the correct amount of oxygen for complete combustion is ignited the rate of ignition is maximum. The rate of ignition is retarded almost equally by a deficiency or an excess of oxygen carried in the air. The ultimate temperature of the products of combustion (flame) is likewise depressed by either excess air or deficiency in air.

It is common in practice to always supply through burners excess air to be certain that oxidation or combustion will be complete and all energy released in the furnace. The amount of excess air required by a burner to assure this is a direct measure of the degree of mixing provided by the burner. Especially does this become important when high unit heat releases are desired.

The important gas laws pertaining to burner and furnace relationship is of course, "The volume a gas assumes is in direct proportion to the absolute tem-

perature and inversely proportionate to the absolute temperature." As absolute furnace pressures encountered in industry are so nearly constant the effect of pressure on volume may be disregarded.

Therefore, when the reaction of combustion of a gas is speeded up, the temperature of the combustion gases will rise as all of the heat is liberated nearer the burner and the combustion gases will expand closer to the burner, tending by expansion to spread over the furnace nearer to the front or burner wall, but this heat distribution can be governed. With increased combustion speeds, it will be seen that much higher heat releases can be secured in a furnace than is possible where secondary combustion takes place.

From this point we must go into the mechanisms of heat transmissions.

We can consider that by propagation of combustion from gases, a mass of heated gas is liberated into the furnace containing a certain amount of heat and having a temperature proportionate to the rate of combustion and somewhat inversely proportionate to the mass occupied. The temperature of combustion will be higher with less excess air, provided combustion is complete to the end products because of less mass and higher again if combustion is completed in less volume of the furnace.

Transmission of heat is accomplished by only three mechanisms, conduction, convection, and radiation. When transmission of heat takes place all three of the mechanisms are employed to some degree and the quantities transferred in furnace designs can be controlled to some degree into each of the three mechanisms. Furnace design, location and distribution of the heat-absorbing surfaces of a furnace are prime factors in governing the heat transmission efficiency of a furnace.

In speaking of the efficiency of a furnace we refer to the amount of heat absorbed by the surfaces, such as tubes, and transmitting this to other fluids, etc., separated from the combustion gases of the furnace by the retaining walls, in proportion to the amount of heat liberated by the combustion in the furnace. The mechanism of absorption of heat through the material of the retaining wall of the fluid will naturally be more by conduction than either by convection or radiation.

In turn, the temperature of the retaining walls, or amount of transmission of heat to the walls, will be more by radiation and convection than by conduction.

The definitions of the three mechanisms of heat transmission are:

Conduction: Transfer of heat from one part of a body to another part of the same body, or from one body to another in physical contact with it, without appreciable displacement of the particles of the body.

Convection: Transfer of heat from one point within a fluid, gas, or liquid, by mixing of one portion of the fluid with another of different temperature. In natural convection, that is, without forced mixing from external source, the motion of the fluid is entirely the result of density resulting from temperature differences within the fluid mass.

Radiation: Transfer of heat from one body to another, not in contact with it, by means of wave motion, of heat rays, through space.

The physical laws governing transmission of heat by three mechanisms are available in any mechanical or chemical engineer's handbook. We use these in the following development of the furnace mechanism without specific quantitative analyses.

When a furnace is operating normally, a condition of stability of heat transmission from the heat liberated in the combustion products to the heat absorbed by the surfaces supplied for that purpose will be essentially established. Conduction, convection, and radiation factors will be established in relatively the same proportions of the total amount of heat transferred.

McAdams, in "Heat Transmission," states in the chapter on radiant heat, "Of the gases encountered in heat-transfer equipment, carbon monoxide, sulphur dioxide, ammonia, and hydrogen are the only ones with emission bands of sufficient magnitude to merit consideration."

In the combustion of the saturated hydrocarbons, McAdams further states, "The constituents, carbon dioxide and water vapor account for the major portion of the radiation of gases in furnace chambers, and no large error is introduced by neglecting the others."

"The amount of heat radiated by any particle is proportionate to the fourth power of the absolute temperature." (This is established in the "Stefan-Blotzmann Law"—$a = 0.172\ p\ A\ (T/100)$ where A = radiating area, p = the emissivity factor of the surface and T = absolute temperature in degree F.)

Gases containing carbon dioxide and water vapor when heated to high temperatures emit invisible infrared rays of radiation. (Mark's Handbook, Third Edition, page 409): *"Under Conditions of high temperature and thick gas layer or high concentration of the radiating constituents, water vapor and carbon dioxide, this mechanism (radiation) of heat transfer from gases to surfaces outweighs that of convection in importance."*

(See "Industrial and Engineering Chemistry, Volume 19, page 888, for calculations of this type.)

In radiant heat transfer from one solid to another, several laws come into effect; one being the emissive power of the surfaces, which is established for most materials, and is equal to the total radiant energy radiated in all directions from the surface of one side per unit of time per unit of area of Btu per hour per square foot.

The intensity of radiation from a surface, designated by, "i" in Figure 1, is the radiant energy emitted per unit of time of solid angle with the apex at the radiating area, per unit of projected radiating area, the projection being onto a plane normal to the radiating beam. Let "dA" (Figure 1) equal a small surface element of a radiating body. Within the solid angle, $d\Theta$, making an angle ϕ with the normal to "dA," let the quantity of energy being emitted from "dA" per unit time equal "dq." Then intensity, "i," of radiation of the surface "dA" in the direction of ϕ is defined by the equation

$$dq = i\ dA\ d\Theta \cos \phi$$

The normal intensity of radiation is that value for "i" when the angle ϕ is zero.

The absorptivity of radiant energy of a surface is that fraction of radiant energy, incident on the surface which is absorbed.

The reflectivity of a surface is that fraction of radiant energy incident on it which is transmitted through it by radiation.

It will be seen that since energy cannot be created nor lost, that the sum of the absorptivity, reflectivity and transmissivity will equal unity. However, for thick opaque bodies or solids the transmissivity equals zero and then the sum of absorptivity and reflectivity will equal unity.

It would require volumes to completely present

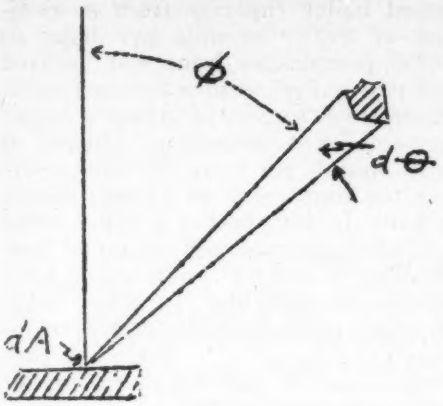


FIGURE 1

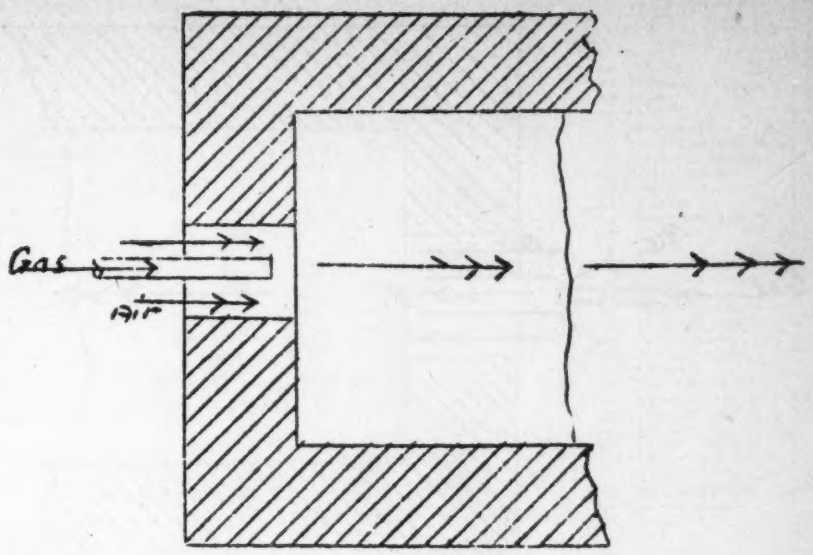


FIGURE 2

the picture of heat transfer but the foregoing presentation is sufficient to draw some positive conclusions regarding the economics of burner selection.

Summarizing generally in regard to refinery practice we find:

Use of air in excess of that required for complete combustion within a furnace will decrease the amount of heat absorbed by the heat-absorbing surfaces without exception. (Stack losses are increased by use of excess air).

In a furnace employing radiant heat tubes and convection tubes, (as commonly understood), the amount of heat absorbed by the radiant tubes will vary directly as the fourth power of the absolute temperature of the mass emanating the radiant energy and inversely as the distance separated from the source of radiant energy.

As a specific example, assume that the products of combustion produced by one burner are at a temperature of 2200° F. and those of another on an identical furnace are at 2600° F. The amount of radiant heat emanated by the products of combustion of the second burner will be $\frac{2600^4}{2200^4} = 1.95$ or 95 percent more than the radiant heat emanated by the first. Likewise the amount of heat absorbed by tubes in radiation would be correspondingly greater for the same rate of fuel consumption in each case.

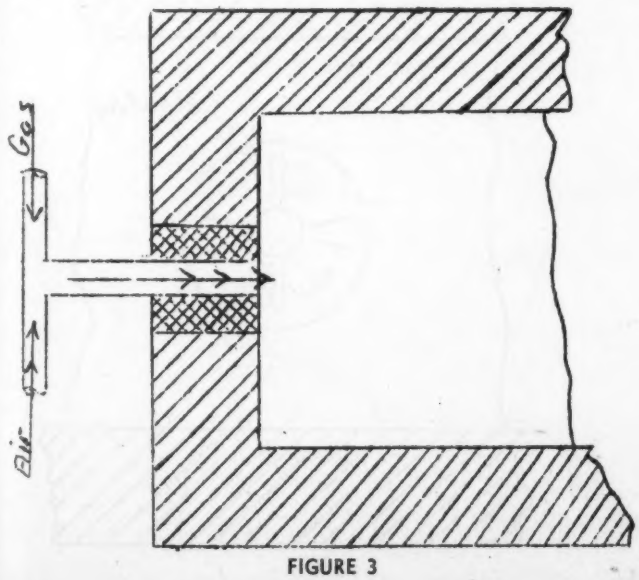


FIGURE 3

As the total amount of heat generated by each burner is identical, then the products of combustion from the first burner will contain materially more heat upon entering the convection section and will be at a larger volume. As a result the convection tubes will absorb more heat than would be the case with the second burner, but in no case can this increase in convection absorption equal the amount lost in radiation. The total heat absorbed from the products of combustion of the burner producing the highest flame temperature will always exceed that absorbed from the products of combustion of the burner producing a lower temperature.

Because a burner produces products of combustion at a higher temperature than another it does not follow that wall or tube surface temperatures will be higher, nor that the amount of heat absorbed per unit area of tube surface will be increased over the maximum unit area absorption in the case of the lower temperature flame.

A burner that produces a lower temperature flame does so for one or both of the following reasons: a. Poor mixing of air and gas at the burner resulting in air and gas strata entering the furnace and consequent delayed complete combustion. b. Excess air is employed.

In the usual refinery furnace a burner should eliminate from the furnace the necessity of serving both as a mixing chamber as well as combustion space.

Heat can not be absorbed until it has been generated. Therefore, if a burner does not deliver a complete mixture of air and gas but instead delivers air and gas strata into a furnace, the chemical reaction of combustion will not have been completed nor the total heat generated until the mixing is completed by furnace currents rather than by the burner. This results in "late" generation of total heat and will result in high temperatures at some depth in front of the burner, flame impingement or local "hot spots."

As CO_2 and H_2O vapor are the important gases that give up radiant energy, if these end products of combustion are produced "deep" in a furnace they will not give up radiant energy to tubes in the front part of the furnace to the same degree as would a

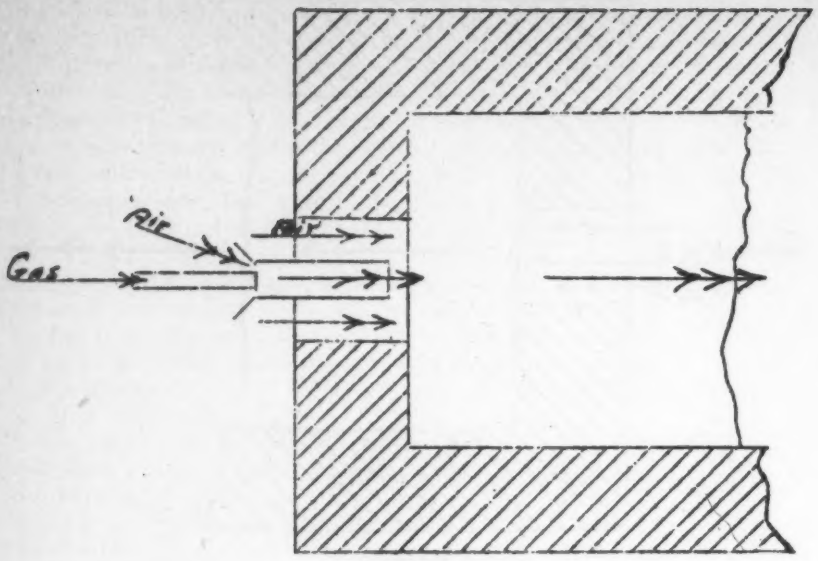


FIGURE 4

burner producing CO_2 and H_2O nearer the burner. Neither would these essential gases remain within the furnace as long when produced further away from the burner and therefore the time element would be decreased, resulting in reduced absorption of radiant heat.

On the other hand, a burner that delivers a homogeneous mixture of air and gas of the proper proportion to a furnace, eliminating from the furnace the necessity of serving as a mixing space, will produce complete combustion to the end products CO_2 and H_2O in the minimum time and at the maximum temperature and at the minimum distance from the burner. (Note: Provided the entering velocity of the mixture is not such as to produce blow-torch action.) As soon as produced, the CO_2 and H_2O molecules emanate radiant energy of the furnace and reduce absorption to the rear of the furnace as compared to conditions previously outlined. This results in more uniform absorption throughout the "radiant" section of the furnace.

The importance of these phenomena can be illustrated by many case histories. In one refinery a simple conversion job increased boiler capacity from a maximum of 90,000 pounds per hour to 130,000 pounds per hour was secured from two boilers with a reduced stack temperature. In another plant a boiler designed for a maximum output of 50,000 pounds per hour has been operating for four years at 75,000 pounds per hour. In yet another a boiler rated at 175,000 pounds per hour is now operating at 235,000 pounds per hour without any difficulty. In a like manner, many oil heaters have secured increased throughputs by the same proportions and at reduced or no higher stack temperatures. There is no intention to set the above up as general conditions, but many more just as bad still exist.

No burner can produce an extra Btu. However, in many instances it is possible that one burner can salvage millions of Btu's over another.

In this respect it is well to note that an improperly engineered installation of a good burner may be as bad an offender as an improperly engineered burner installed in the best possible manner.

In all figures:

——————→ indicates raw gas.

——————→→ indicates air.

——————→→→ indicates partial mixture of gas and air.

——————→→→ indicates complete mixture of gas and air.

It is not necessary to comment on the rapidity and completeness of mixing secured from the four basic designs illustrated.

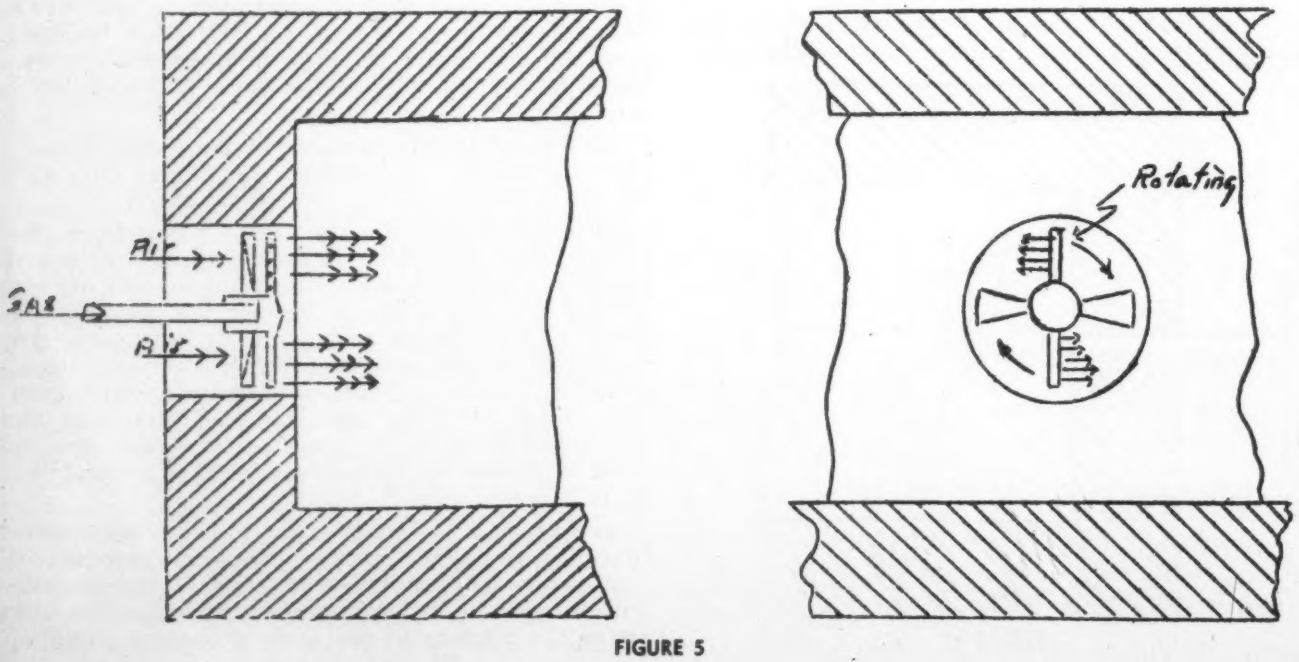


FIGURE 5

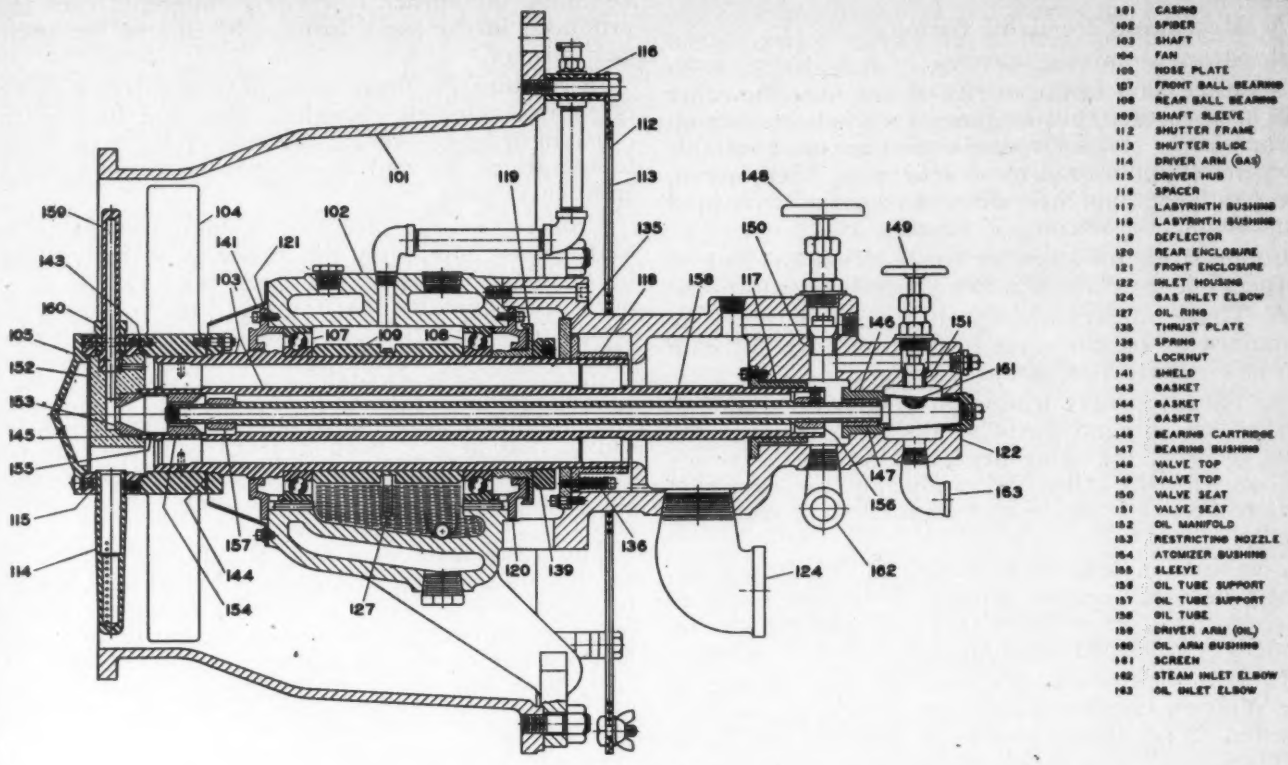


FIGURE 6

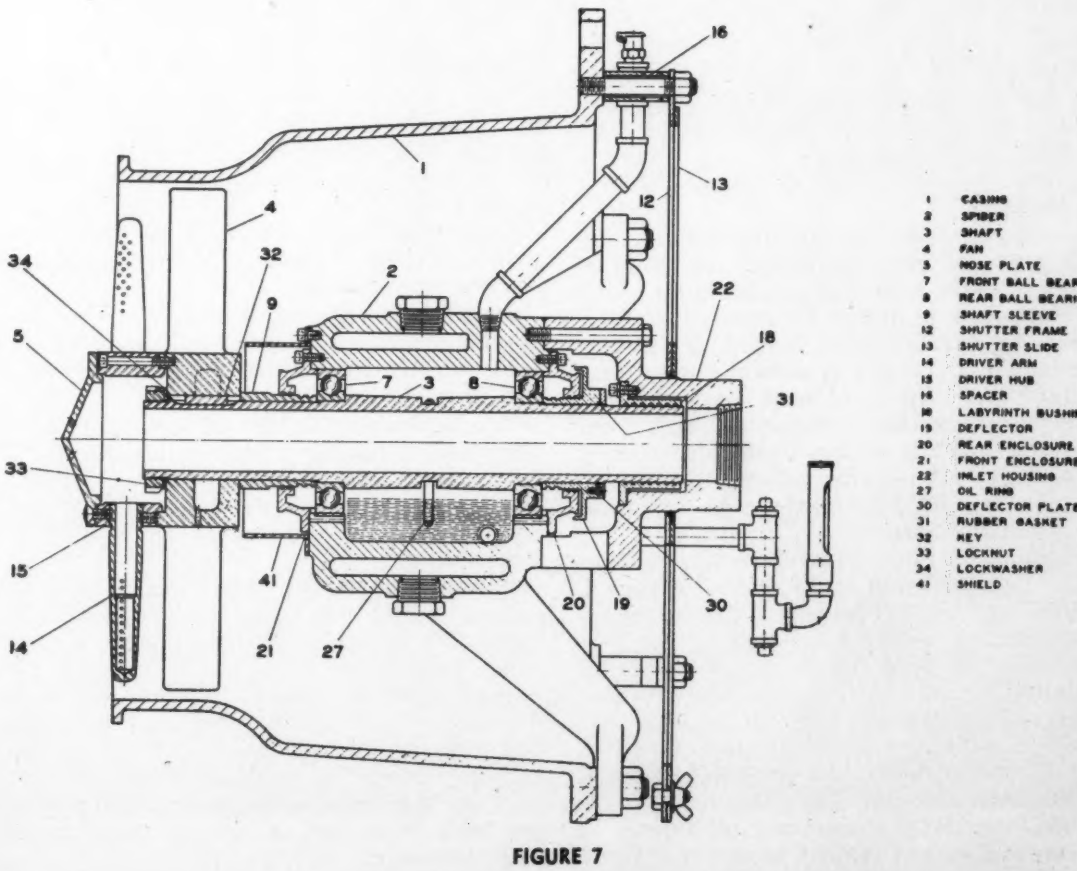


FIGURE 7

Oil burners are generally put into one of two classifications.

A. Mechanical atomizing burners.

B. Steam atomizing burners.

No discussion of the merits of one over the other will be presented, but in general we believe that oil burners using steam for atomization are more suitable for general application in oil refineries. Their advantages outweighing their disadvantages as compared to mechanical atomizing oil burners.

Combination, or so-called combination gas and oil burners may be classed in two general classifications:

A. Those burners where two separate burners are combined to use the same furnace opening but both burners operate as separate units.

B. Those burners where the gas burner and oil burner are integral parts of the same mechanism, thus securing the same degree of mixing with one fuel as with the other and producing the same heat pattern on either fuel or on both fuels simultaneously fired.

Combination burners in Class "B" have only recently been put on the market (in limited numbers temporarily), after three years of proving on oil heaters in a Southern and Mid-Continent oil refinery.

In 1939, before the Wichita, Kansas, meeting of the Western Petroleum Refiners Association, a paper entitled "New Developments in Burners and Their Applications," was presented and later published in the October, 1939, issue of PETROLEUM REFINER.

This paper dwelled at some length on the performance of gas burners in Classification "D," Figure 5, which at that time was entirely new to Mid-Continent refiners. At present, there are over 1000 installations of this type burner in various oil refineries, many of which are in the Mid-Continent.

Figure 6 is used in this article to show the mechanical design of this type gas burner in order to correlate the description of the combination gas and oil burners, falling in Class "B," combination burners, which are yet new in the industry.

Figure 7 shows the mechanical details of the new combination burner.

In the conventional oil-burner atomizer oil spray is ejected under pressure from the burner tip which is centrally mounted in the burner casing through which the air for combustion is drawn by furnace draft or through which air is forced by forced draft. The spray of atomized oil generally is conical but in some instances a flat shaped spray is used. Curved vanes generally are placed at the entrance to the burner casing to impart a swirling motion to the air entering the furnace in order to speed up mixing of air with the burning oil spray in the furnace, with resultant shorter flame from the burner.

The conventional oil burner therefore can be compared directly to a gas burner of Type "A," Figure 2, where the "fuel" and air are mixed in the furnace—during combustion.

In most oil refinery applications a gas burner of Type "A," Figure 2, would be completely undesirable due to the delayed combustion secured resulting in a long flame and less efficient operation than would be secured from any other of the four general classes of gas burners illustrated.

In a like manner the conventional oil burner is objectionable as it does not remove from the furnace the necessity of serving both as mixing space as well as combustion space.

The heat pattern of a furnace fired with the conventional oil burner is entirely different from that produced in the same furnace by one of the better gas burners.

In combination firing of oil heaters extreme care is often necessary in changing from one fuel to the other in order to prevent material changes in charge temperatures as well as to prevent "header leaks" from developing.

Unlike gas, oil produces a luminous flame no matter how finely may the oil spray be "pulverized" or atomized unless it is burned with excess air of such great quantity that the heat loss to stack gases would be prohibitive. A "flameless" or "blue flame" oil burner may be all right for a cook stove but entirely unsuited for refinery furnaces.

The chemistry of combustion of fuel oil is not unlike that of gas. Both hydrocarbons and the end products of combustion are CO_2 and H_2O. The oxidation reactions in burning oil are simply more complicated.

The gas burner of Class "D," Figure 5, was developed on the logic that Bunsen's ideal burner could be simulated by using orifices of relatively limited numbers moving rapidly across the entire air stream and discharging the gas *transverse* the air stream. The same logic was used in designing and developing the oil burner part of the combination burner of Class "B," Figure 7.

Referring to Figure 7, it will be noted that a conventional type steam atomizing oil gun is built integral in the center of a gas burner of Class 4, Figures 5 and 6. Instead of the atomized oil going into the conventional center "tip" after atomization, it will be noted that it goes into oil "driving arms," Part No. 159, Figure 7, and from these arms is discharged through orifices (not shown on drawing as half of arm is shown cut away), drilled at different radii from the center of rotation and essentially transverse the air flow through the casing. The reaction of the atomized oil jets from the orifices furnishing the necessary energy to "drive" the fan at proper speed to deliver the correct amount of air to the furnace.

By comparison it will be noted that the gas burner part of Figure 7 remains the same as a Class "D" gas burner shown in Figure 6.

It will be further noticed that essentially the same degree of mixing of either gas or oil will be secured across the entire air stream and before entrance into the furnace.

A combination burner (or straight oil burner) of this design, having a throat diameter of 15 inches, operating at a heat release of 20,000,000 Btu per hour from oil, will have a flame length of three feet and less than 10 percent excess air in the products of combustion.

In furnace design the question has often been raised: Should the furnace be designed for the burners to be used, or should the burners be designed to the furnace?

We believe that the burners should be designed to the furnace and to the process. The burner manufacturer should be given as much detailed information as possible on the application and service and not only asked to bid on burners to deliver so many Btu's per hour from fuel of certain specifications and at some pressure.

Whenever burners are moved from one service to another or in the event fuel specifications have

changed since installation, the burner manufacturer should be contacted, advising what the changed duty will be and at the same time giving the burner number. A manufacturer who maintains proper engineering records at the factory can then advise if any changes should be made in the orifice drilling to secure maximum efficiency under the new conditions. Orifice drilling changes should be engineered whenever possible and not made by hit or miss methods.

Burners should never be purchased on first-cost figures. A burner that is one percent less efficient for a specific job than another will eventually cost many times more than the more efficient burner, even if it were delivered to the user free of charge.

We have covered proper design of fuel systems, maintenance of same, possibilities of economics by use of waste heat recuperative equipment and proper selection of burner equipment. If every oil refinery will carefully study all furnaces now in operation and carry out the improvements that will conserve fuel in only those instances where the savings will pay a handsome return on the investment, they will have effected the greatest fuel saving of all time. At the same time a most splendid example will be set for other industries.

This paper has not dealt on the importance of maintaining clean tube surfaces in boilers, heaters and other heat transfer equipment nor the economics often available by use of super-positive steam-electric stations in oil refineries of relatively large capacity. This does not detract from their importance. A separate paper could be written on those subjects.

It should be stated, however, that a superposition steam-electric power plant will pay for itself in six years in any refinery that burns an equivalent of 1000 barrels of oil per day in the boiler plant and will effect approximately a 15 percent reduction in fuel consumption for steam generation. With respect to superposition steam generation, it might be noted that in some instances superposition offers as an attractive investment for smaller oil refiners as to large. For instance, a refinery having a total demand for steam in the amount of only 100,000 pounds per hour at a pressure of 150 pounds per square inch and an electric demand of approximately 1000 KW per hour or more offers good possibilities in this direction.

Under such conditions a steam generator of 45,000 to 50,000 pounds per hour at 475 pounds pressure and 560° T.T. of steam together with a 1000 KW back pressure turbo-generator (topping unit) with exhaust pressure at 150 pounds might prove to be a very profitable investment to a refiner. It is suggested that superposition has not been given proper thought in relatively small plants and that this "high hat" attitude has been a mistake.

The "economics of combustion" resolves simply to "conservation of fuel," and this important matter certainly deserves careful study in the oil-refining industry.

The burner manufacturers are responsible to the oil industry to continue to improve combustion equipment and deserve the full cooperation of the oil industry in working in that direction.

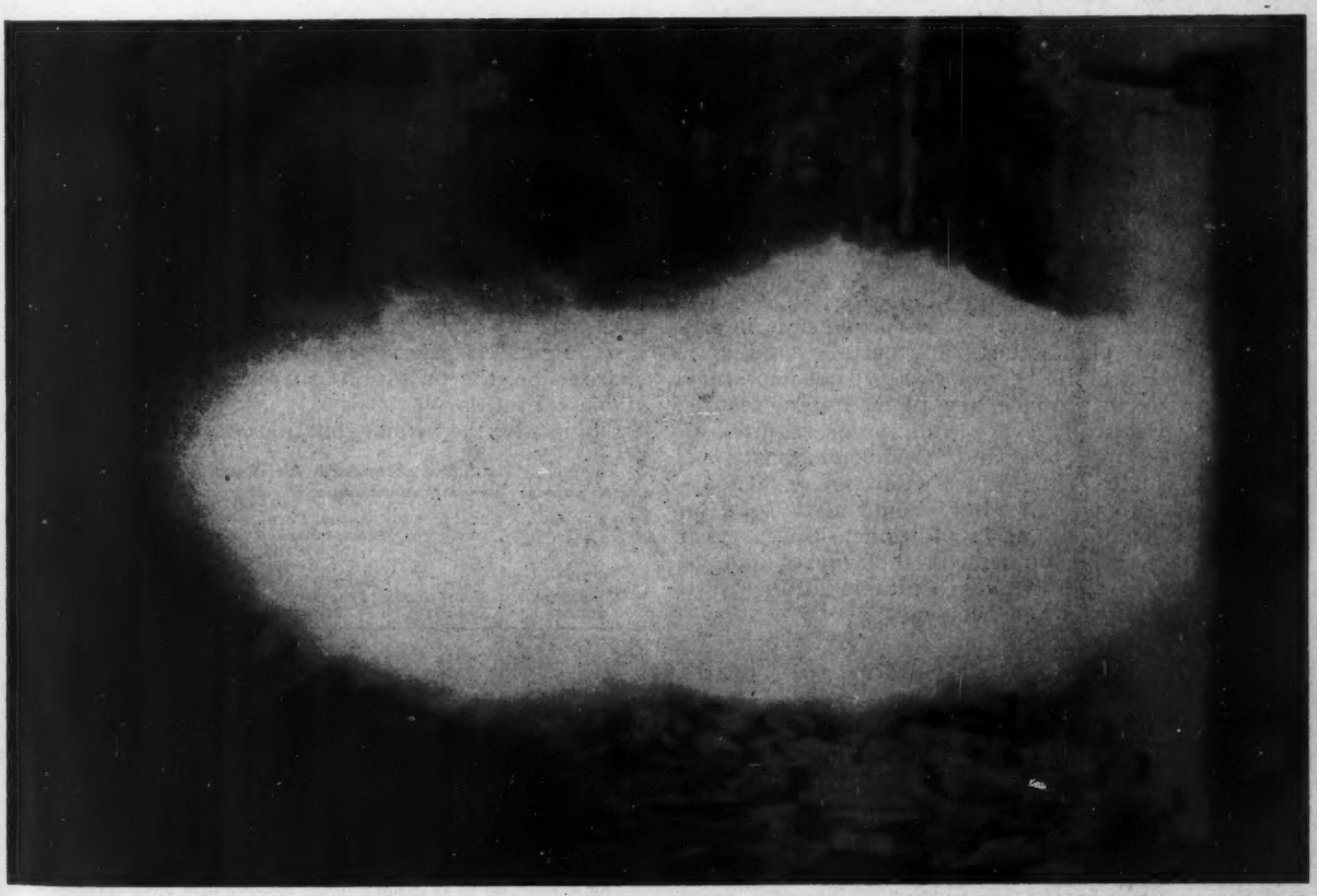
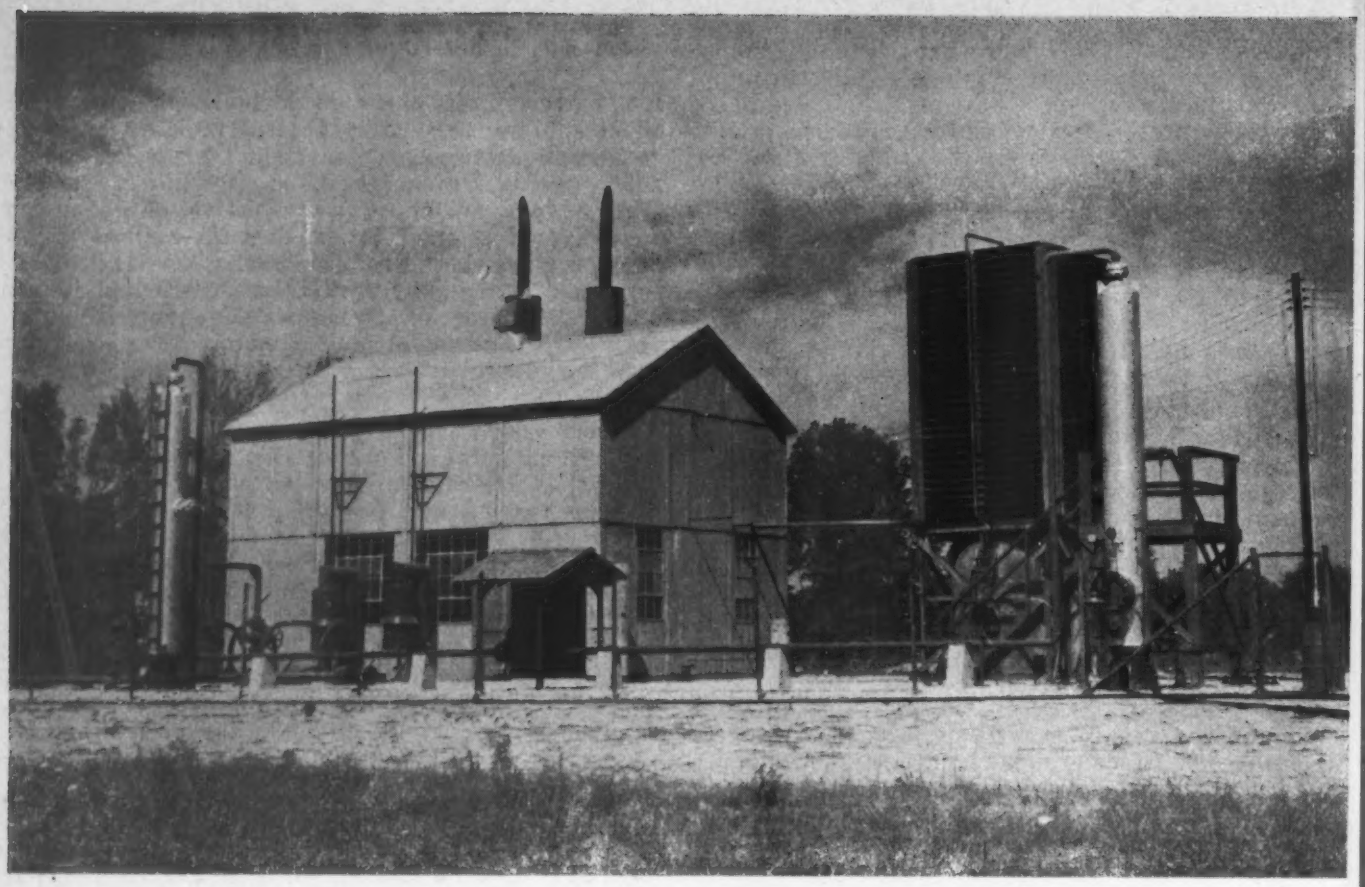


FIGURE 8

Class B combination oil and gas burner, operating on oil at rating of 21,000,000 Btu per hour. It is mounted in a box type furnace with center line 24 inches above the furnace floor. The burner is 15 inches in diameter. Rubble on the furnace floor is to increase radiation to the side walls.



Compressed Air Institute Urges More Complete Use of Compressor Auxiliaries

WHILE the compressor is the prime unit in any compressed-air plant, there are certain auxiliaries thereto which are vitally important, if not necessary, if the plant is to produce overall maximum results. As a rule, practically every compressor requires an air receiver of ample size, and, in addition, most compressed-air plants should use aftercoolers. An approved and efficient air filter should always be installed in the suction, and in addition to this, a great many protective instruments in the way of gauges, thermometers, relief valves, suitable drains, etc. should be installed when necessary.

Air Receivers

In every compressor installation, the air receiver forms an essential part. It not only absorbs pulsations in the discharge of the compressor, but also acts as a reservoir for the storage of compressed air, furnishing some reserve capacity to compensate for instantaneous demands in excess of the compressor capacity. It also acts as a condenser for some of the moisture present in the air or gas as it comes from the compressor, and to collect such condensation that may pass the aftercooler, keeping same from entering the distribution system. Receivers are also necessary to supply uniform pressure for governing instruments. If governors are connected to the discharge line, the pulsations therein will result in unstable operation.

Obviously, the proper functioning of this accessory

A.S.M.E. Standard Air Receivers

Diameter, Inches	Length, Feet	Actual Compressor Capacity for which Receiver is Suited, cu. ft. Free Air Per Minute[1]	Volume, cu. ft.	Types of Opening for Cleaning
14	4	60	4½	Openings for inspection and cleaning are required and must meet specification of A.S.M.E. Code for Unfired Pressure Vessels.
18	6	95	11	
24	6	185	19	
30	7	305	34	
36	8	450	57	
42	10	640	96	
48	12	1,275	151	
54	14	1,900	223	
60	14	3,000	275	
66	18	4,500	428	

[1] For automatic start-and-stop service, extra large receivers are recommended to avoid starting too frequently.

All receivers up to 42 inches x 10 feet inclusive have screw openings—48 inches x 12 feet and larger have flanged inlet and discharge openings. Vertical receivers must have base to raise them 6 inches above floor to permit hammer test by inspector.

Receivers are furnished complete with safety valves, pressure gauge, hand holes or manhole as required by code, drain valve and nipple, and base for vertical receivers.

is essential to the overall efficiency of the compressor assembly, and any weakness will be revealed in faulty operation of the compressed air plant.

The Compressed Air Institute endorses only air receivers that meet the requirements of the ASME code, and has standardized on a line of such receivers, in sizes and capacities shown in the table for discharge pressure up to 125 pounds per square inch. Relieve valves must not be set higher than the pressure stamped on the tank.

Aftercoolers

Aftercoolers are advisable, if not absolutely necessary, in nearly every air-compressor installation as a means of removing water and oil vapors by means of condensation. Compressed air or gas contains moisture in some degree, dependent upon the condition of the air taken into the compressor. As the air is compressed, it does not condense its moisture because of the rise in temperature that accompanies compression, and thus it is carried along as a vapor through the receiver and into the pipe line. The temperature of the compressed air falls rapidly in the discharge line due to radiation, resulting in much water being condensed in the line, which, aside from being objectionable in the line for many reasons, is very destructive to pneumatic tools or other mechanical equipment in which the air is used.

It is to force this precipitation by lowering the temperature of the air before it enters the discharge line that aftercoolers are employed. They are installed near the compressor to condense the moisture before it has a chance to enter the line, and should be installed with an automatic trap to dispose of the condensation as it occurs.

Aftercoolers are of the shell-and-tube type and of course depend for satisfactory performance upon the use of the coldest water available. Obviously, unless the aftercooler is of liberal size, cooling will be incomplete, which means that the maximum amount of water will not be removed from the air. The importance of installing aftercoolers of proper design and capacity is indicated by the accompanying air-reaction chart (See Figure 1).

It will be noted that if 1,000 cubic feet of saturated air is drawn into a compressor at atmospheric pressure and at a temperature of 70°F., it will contain 1.12 pounds of moisture. This moisture will, some where along the line, condense, and the water pass into any mechanical equipment for which the air is used, causing very rapid wear of these parts. Much loss of time and loss of compressed air is also caused by the necessity for the operator blowing out the air lines each time he uses compressed air for blowing away chips and for similar purposes because of the water present in the line.

Aftercoolers also present an element of safety in every compressor plant. In case any carbon accumulating on the walls of the discharge pipe should become incandescent and starts to burn (which condition might occur with careless operation such as using too much oil of inferior quality and, if in addition, valve and piston leakage exists) the fire is promptly quenched as soon as it enters the aftercooler and no harm occurs.

Air Filters and Silencers

It is usual practice to run the intake pipe to the outside of the building in order to obtain as cool air as possible. Atmospheric conditions vary, with winds carrying much dust and grit. As a result, the air compressor inlet must be provided with air filters, to prevent this dust and grit from passing into the compressor, where it causes rapid wear of the working parts, as well as combining with the lubricating oil as a binder and forming obstructive and abrasive coating on cylinder, valves, etc. The carbon sometimes found on valves, discharge pipe, etc. will be found upon analysis to be mostly dirt with some oil, which can cause leakage by getting under the compressor valves. Such gritty deposit will also add to the rapid wear of moving parts.

The use of filters on the intake can also be classed as an element of safety in operation, since the elimination of sand will remove one hazard that might

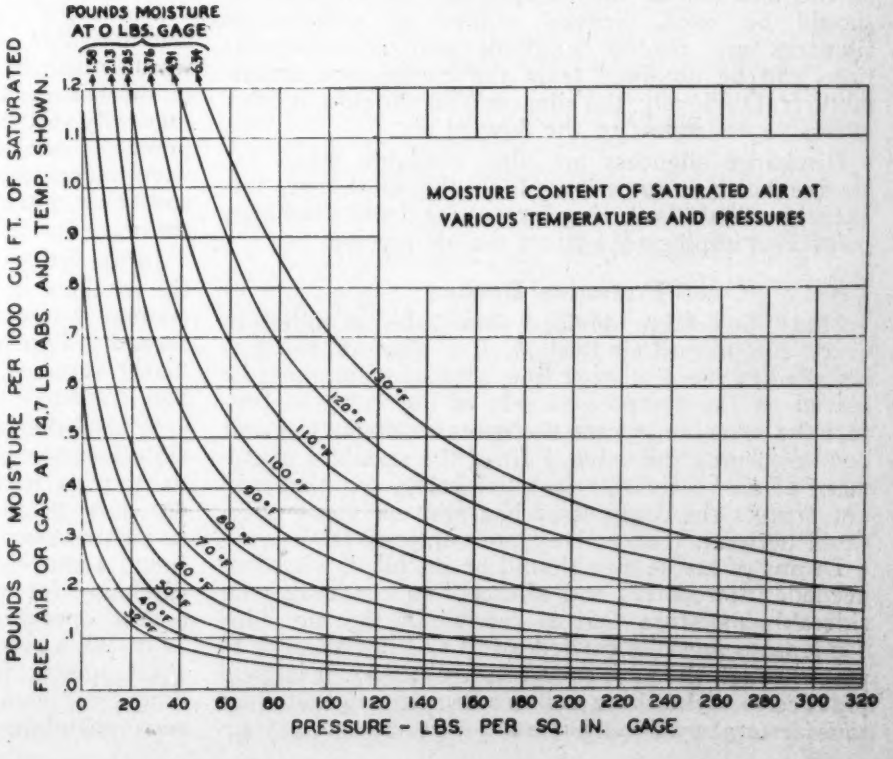


FIGURE 1

Weight of moisture per thousand cubic feet of saturated air at various pressures and temperatures.

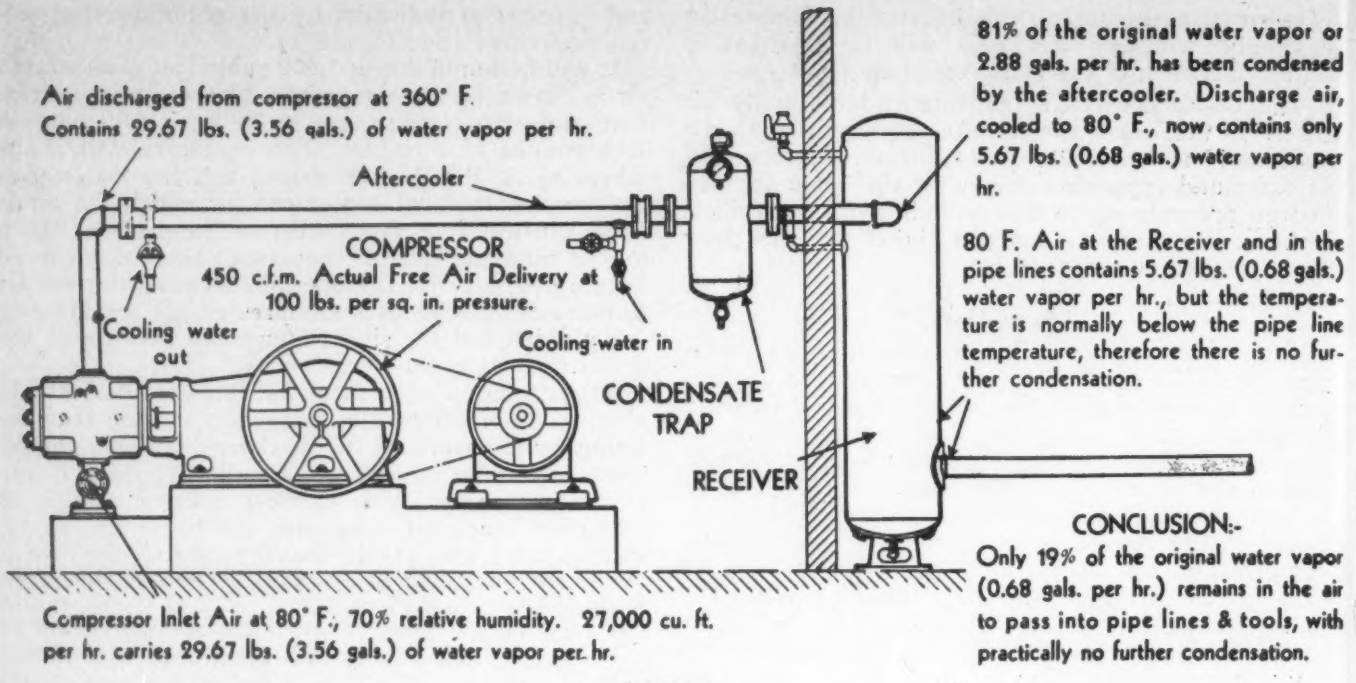

Air discharged from compressor at 360° F.
Contains 29.67 lbs. (3.56 gals.) of water vapor per hr.
Aftercooler
COMPRESSOR
450 c.f.m. Actual Free Air Delivery at
100 lbs. per sq. in. pressure.
Cooling water out
Cooling water in
CONDENSATE TRAP
RECEIVER
81% of the original water vapor or 2.88 gals. per hr. has been condensed by the aftercooler. Discharge air, cooled to 80° F., now contains only 5.67 lbs. (0.68 gals.) water vapor per hr.
80 F. Air at the Receiver and in the pipe lines contains 5.67 lbs. (0.68 gals.) water vapor per hr., but the temperature is normally below the pipe line temperature, therefore there is no further condensation.
CONCLUSION:-
Only 19% of the original water vapor (0.68 gals. per hr.) remains in the air to pass into pipe lines & tools, with practically no further condensation.
Compressor Inlet Air at 80° F., 70% relative humidity. 27,000 cu. ft. per hr. carries 29.67 lbs. (3.56 gals.) of water vapor per hr.

FIGURE 2
Compressor installation complete with aftercooler

produce a spark where operation is sufficiently faulty to cause a combustible mixture to form in the discharge line.

Efficient commercial intake filters have become so standardized and relatively cheap that the earlier method if installing a home-made filter of questionable efficiency is no longer justifiable. The compressor manufacturer best knows what size and type of filter will give best service with his compressor, with the least pressure drop in the lines. If possible, a suction filter should not cause a pressure drop in the suction line of more than roughly 2 inches of water.

When the noise of the suction is objectionable due to the location of the compressor, an air silencer should be used. Several makes of satisfactory silencers are readily available and recommendations can be obtained from the compressor manufacturer. Obviously, the silencer also should not offer excessive resistance to the flow of air.

Discharge silencers are also available when excessive noise is experienced on the discharge, frequently called "tank ring," resulting from discharge pulsations impinging against the air receiver.

Protective Devices

Many protective devices should be installed in every compressed-air system. If a shut-off valve is installed in the discharge line, a relief valve must be placed on the compressor side of the valve to protect the machine in case the operator starts the unit before opening the valve. Part of the standard equipment of air receivers is a relief valve, but that will not protect the compressor if a shut-off valve is located between the receiver and compressor.

Drains of ample size should be installed, wherever needed. Intercoolers and aftercoolers condense considerable moisture that is carried in the air. This condensate must be carried away and not allowed to pass through the next compressor cylinder. It is good practice to make these drains automatic so that their satisfactory functioning is not dependent upon attention by the operator, but care must be exercised to insure that the automatic trap works, which is not always the case.

In many cases, especially on the larger steam-and gas-engine-driven compressor equipment, an overspeed shut-down is desirable; such machines usually have limiting speed governors as standard equipment, whose purpose is to limit the maximum speed of the machines. However, in case these governors should stick for any reason when the machine tries to overspeed, a device can be installed that will function to shut down the compressor. This device, if not standard equipment on the machine, can be obtained at a small extra cost.

For larger equipment, an oil-failure shut-down is also desirable, since on the larger machines oil failure would result in a considerable repair charge. In case of oil failure, the unit is usually shut down automatically, although in certain installations, such as process work, shut down of the equipment may be very undesirable, and in such cases the device could sound an alarm to give the operator warning that there is something wrong with the oiling system.

Jacket-water-failure shut-down is a protection for the machine in case the operator fails to turn on the cooling water or in case the cooling water supply should fail for any reason. This device, while not regularly supplied with compressor equipment, may be had at a small additional cost.

Where the compressor is installed in an inaccessible location or where the operator can make only daily trips to inspect the machine, it is frequently desirable to add additional protective devices; such as a shut-down from excess pressure in the discharge lines; a shut-down due to excess temperature on the discharge for any reason whatsoever; in the case of special operations, it is sometimes thought advisable to install a recording discharge gauge or a recording thermometer to record these operating conditions. The compressor manufacturer will be glad to make recommendations for any special features.

Foreign Processes for the Conversion of Methane to Hydrogen And Carbon Monoxide

HEINZ HEINEMANN

DALTON showed in 1809 that methane could be decomposed to carbon monoxide and hydrogen by electric sparks. Bunte[1] decomposed coal gas at 1100° to 1200° C. with a volume increase of 40 percent. The gas which originally contained 31.9 percent methane was reduced to a methane content of 5.8 percent when heated in the presence of iron, of only 1.6 percent when heated in the presence of coke. The hydrogen content increased from 47.9 to 81.4 percent.

In a German patent[2] Nauss describes the cracking of methane in the presence of nickel- or cobalt-impregnated clay at 1000° to 1200° C.

Lang[3] investigates the influence of steam and carbon dioxide on methane. A surplus of steam (at least two parts per part of methane) is used and passed at 1000° C. through a clay-filled reaction tube. The resulting mixture consists of approximately equal parts of hydrogen and methane. About 10 percent carbon monoxide and carbon dioxide are obtained.

Dieffenbach[4] claims a process for the manufacturing of hydrogen by reacting steam and hydrocarbons at high temperatures for brief periods. He employs wire gauze of cobalt, nickel and platinum as catalysts.

In another patent[5] hydrogen is obtained from hydrocarbons and steam in the presence of a nickel catalyst at a temperature which surpasses red heat. The nickel is supported by a magnesium oxide carrier. The nickel may be mixed with other metals or metal oxides and a reaction temperature of 800° to 1000° C. is recommended. Mixtures of hydrocarbons and air and steam are alternatingly passed over the catalyst.

Bergius[6] manufactures hydrogen from methane at 1100° C. by treating it with steam and obtaining carbon monoxide as a by-product.

Other patents describe the reaction of hydrogen and steam in the presence of nickel, cobalt or iron which has been activated by difficultly reducible oxides of metals like chromium, vanadium, potassium, magnesium, aluminum at 300° to 650° C., the incomplete combusion of methane with oxygen to carbon monoxide and hydrogen, etc.

A fundamental study of suitable catalysts was made by Fischer and Topsch[7]. Mixtures of methane and carbon dioxide in a ratio of 1:1 are passed over catalysts. Copper and tungsten catalysts on carrier supports were found to be ineffective, while molybdenum was little effective. Iron catalysts of small efficiency could not be improved by the addition of alumina. Most effective were nickel and cobalt catalysts which show about the same activity and can be promoted by alumina, which in itself is no very good catalyst. With nickel catalysts on alumina supports an optimum conversion was obtained and the effluent gas had the following composition:

CO_2	4.3 Percent
O_2	0.4 Percent
CO	45.2 Percent
H_2	44.6 Percent
CH_4	2.2 Percent
N_2	2.8 Percent

The same paper[7] discusses the reaction of methane and steam and finds catalysts of nickel-alumina or cobalt-alumina on supports as superior to others. A complete reaction is obtained at a temperature of 860° C. and a space velocity of 600. An increase in temperature (e.g. to 930° C.) enables a far going conversion at increased space velocities (e.g. 2500). In order to obtain carbon monoxide and hydrogen as main products in the combustion of methane, this should take place on large catalyst surfaces which accelerate reaching the equilibrium[8].

The industrial application of the conversion of methane to hydrogen and carbon monoxide is discussed by Berthelot[9]. The easiest way to convert methane consists of its partial combustion according to one of the following reactions:

(a) $CH_4 + H_2O$ (vapor) $= CO + 3\,H_2 - 50$ cal.
(b) $CH_4 + 2\,H_2O = CO_2 + 4\,H_2 - 40$ cal.
(c) $CH_4 + \frac{1}{2}\,O_2 = CO + 2\,H_2 + 7$ cal.
(d) $CH_4 + CO_2 = 2\,CO + 2\,H_2 - 60$ cal.

Reaction (d) takes place at 850° to 900° C.

The industrial realization of reactions a-c presents great difficulties. Side reactions such as the formation of olefins, acetylenes and aromatics must be avoided. Without a catalyst, the minimum reaction temperature for the reaction between methane and water is 1200° C. The endothermic reactions (a) and (b) bring with them great difficulties in the construction of suitable equipment, due to the high temperatures required. Reaction (c) is exothermic and the temperature control is difficult as complete combustion of methane must be avoided.

In the presence of catalysts the whole problem is greatly simplified because temperatures for the reaction between methane and water are reduced to about 760° C. Russel and Hanks use at this temperature a catalyst consisting of alumina or oxides of rare earths impregnated with finely divided nickel

or cobalt. The search for a suitable catalyst is concentrated on finding an active and physically stable mass of long life which is not easily poisoned by such by-products as are formed in the course of the reaction. One method of preparation is to impregnate an aluminous cement with nickel or cobalt nitrates and to calcine the mixture. The oxides are then reduced by means of hydrogen. The powder obtained is then mixed with black nickel oxide, formed into cubes and heated to 1000° C. in a hydrogen atmosphere. Other catalysts proposed consist nearly always of nickel of cobalt associated with alkaline earths, or oxides of rare earths, the mixtures being calcined at temperatures below those at which the elements fuse.

In a European industrial process the procedure is based on the decomposition of methane in the presence of oxygen and water. The first reaction delivers the heat necessary for the decomposition of methane. The methane, oxygen and water are heated in a series of heat exchangers and passed over a catalyst consisting of activated nickel on a refractory support. Less than 1 percent of methane remains in the effluent.

More recently Japanese scientists have investigated methane conversions. Ogawa, Matui and Senvo[10] introduce methane at the rate of 2 liters per hour into a porcelain tube containing 200 grams of powdered iron oxide. The tube is 2.6 cm. in diameter and heated by an electric furnace to 900, 1000 and 1100° C. The gases produced by the reaction are analysed at intervals for methane, carbon monoxide, carbon dioxide and hydrogen and the results are plotted. At first the reaction yields carbon dioxide and water, then chiefly carbon monoxide and hydrogen at a constant ratio of approximately 1:2 for several hours and finally the concentration of hydrogen increases owing to the reaction $CH_4 = C + 2\ H_2$. At 1100° after 2.5 hours, the product consisted of about 21 percent CO and 40 percent H_2. The catalyst was regenerated with a limited amount of oxygen in a separate vessel. When bog iron ore is substituted at 1100°, 20 percent CO and 45 percent H_2 were obtained after 2.5 hours. When bog iron ore was completely reduced and regenerated with a limited amount of oxygen, the production of CO and H_2 was fairly constant at 22 to 24 percent of CO and 58 to 60 percent of H_2.

Tutumi noted[11] that an addition of 3.3 to 33 percent of potassium carbonate to nickel catalysts will tend to decrease the reaction rate.

Coura and Huzdmura[12] describe the reaction of methane and steam at relatively low temperatures in the presence of catalysts. The decomposition of methane and the volume of CO_2 produced increase with the amount of steam, but this action is less marked when the amount of steam exceeds that of methane seven times. The catalyst activity is increased by addition of alumina or of magnesia. Kaolin provides the best support. The activity of the catalyst depends on combustion and reduction temperatures. It improves as the temperatures are reduced. Best results were obtained at 600° with a water : methane ratio of 7:10 and using a nickel-alumina-kaolin catalyst in the proportions of 1:0.043:10. Combustion temperatures of 500° and reduction temperatures of 300 to 500° are recommended and an amount of catalyst corresponding to 1 percent of the volume of methane per hour is required.

Ogawa, Matui, Nagai and Senvo[13] prepare mixtures of approxmately $1\ CO : 2\ H_2$ by alternately passing at a rate of 3 cm per hour methane:air mixtures (which burn to produce a temperature of 1380°) and methane (which absorbs heat on cracking and lowers the temperature to 1220°) through a nickel-chromium alloy tube containing a nickel catalyst and ignited iron balls made of equal amounts of ferric oxide and magnesia. The exit gas from a typical run had the following composition: CO_2 — 3.5 percent, O_2 — 0.9 percent, CO — 21.8 percent, H_2 — 56.5 percent, CH_4 — 16.3 percent and N_2 — 1.0 percent. The amount of conversion was increased by putting nickel-kaolin balls above the iron balls in the tube. In a typical run with the latter arrangement, the exit gas contained: CO_2 — 8.7 percent, O_2 — 0.9 percent, CO — 27.4 percent, H_2 — 56.7 percent, CH_4 — 3.6 percent and N_2 — 2.7 percent.

A special two-compartment oven, filled with coke, for the generation of $2\ H_2 + CO$ from CH_4 is described by the Gesellschaft fuer Linde's Eismaschinen[14]. Enough oxygen to effect the conversion and maintain the right temperature (1300°) is fed through the bottom of the oven. Water vapor is added to both the feed gas and the oxygen. The two compartments operate alternately. The oven is provided with a device to tap the slag.

Ogura and Nagai[15] describe a vertical decomposition furnace, containing kaolin, alumina gel, colloidal ferric hydroxide, cobalt or nickel hydroxide or copper hydroxide which is heated while natural gas is passed through it and made to react with carbon dioxide or with a mixture of carbon dioxide and air.

A. Lotteri[16] states that by using nickel catalysts it is possible to obtain directly from methane and oxygen mixtures of hydrogen and carbon monoxide in the ratio 2:1. The reaction is nearly complete at 880 to 950° C.

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Pressure Distillate Stabilizer And Butane Recovery Unit Come Out of Junk Heap

WHEN the manager of an inland refining plant succeeded in getting adequate priority rating for the material essential to providing two fractionating towers, he thought his problem of controlling pressure on his cracked distillate and recovery of butane had been solved. He made the rounds of fabricating shops and learned that six months was the shortest period of waiting that faced him.

That was too long, so he began scouting yards and other refining plants in search of old columns which could be converted to his use. This proved fruitless.

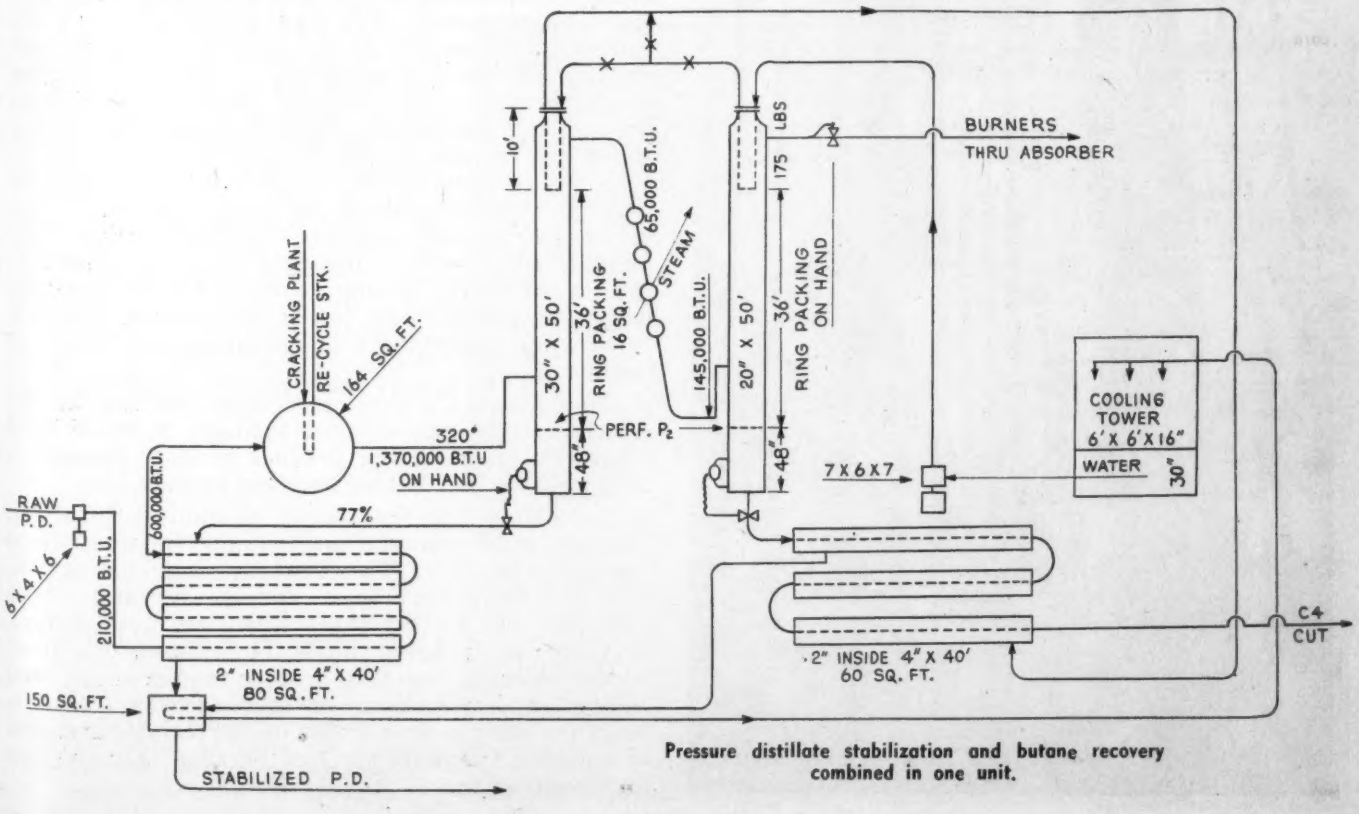
He did, however, find the top 10 feet from a high-pressure stabilizer, 20 inches in diameter, as well as two tube bundles from a salvaged heat exchanger, one 10 feet long, the other 20 feet long.

With these as a nucleus the plant engineers designed and erected two columns which have produced the required-vapor-pressure cracked gasoline and recovered satisfactory amounts of butanes.

To build the fractionating column for which the 10-foot section was obtained, two joints of 20-inch pipe were welded together and installed on a short mounting skirt attached to a conventional base allowing self-support. Four feet above the bottom head a perforated plate was welded inside to support the packing, substituted for trays and bubble caps normally employed in such towers.

New plates with caps were not available, neither could used material be obtained, so, it was decided to fill the tower with thread protectors from two-inch pipe. The protectors were poured into the column, falling in a heterogeneous mass to a point 36 feet up the column.

When the 10-foot stabilizer section was attached to the top of the column, a heavy bolted man-hole flange was connected by welding so that a suitable opening would be provided in which to insert the 20-foot tube bundle, suspended from the top flange by the tube sheet. The cover, a blind flange, was finished with a rib so that, when bolted down tightly against the tube sheet and separating gasket material, a two-pass bundle would be presented for water to flow from the inlet, down through one half, and up and out through the other half of the tube bundle. This tube bundle inserted in the top part of the tower operates as a reflux condenser which in conventional operation would be mounted in a shell



Pressure distillate stabilization and butane recovery combined in one unit.

Piping from the pressure distillate overhead to the inter phase heater. The gin pole at the top of the column is for removal of tube exchangers, which serve as reflux controllers.

The inter phase heater which steps up temperature of the overhead discard from the pressure distillate stabilizer before it enters the C_4 column.

at the top of the column, or on supports near the ground.

The second tower, in reality the first of the series, has a diameter of 30 inches and also is 50 feet high. The shell of this column was made from approved steel rolled in the form of cylinders and afterwards completed at the plant. This column also has a perforated supporting sheet 48 inches up the column from the bottom head.

Ring packing fills 36 feet of this column. The top of the column is equipped with a heavy bolted flange cover which closes the opening through which the 10-foot section of tube bundle is inserted. Two-pass circulation is obtained for water, provided by fittings and apparatus similar to the 20-inch tower. Raw pressure distillate is pumped through a counter-flow exchanger handling the raw material passing in and the stabilized pressure distillate passing out. The exchanger is constructed of 4-inch pipe, as the shell, containing one pass of 2-inch pipe internally. Salvaged tube headers are welded to the pipe for continuous flow.

From this exchanger, the pressure distillate passes through a heater containing 164 square feet of heating surface, and enters the column at 320° F. The top temperature of 120° F. permits passage of sufficient light fractions to produce a bottom product of required vapor pressure.

The overhead from the first column enters a heater installed between the columns. This heater forms part of the first-column vapor line, and ends with the charge line to the second column. Both columns are operated at practically the same pressure so that the overhead from the first column will flow to the second. The process pressure is controlled at approximately 175 pounds by a double-pilot pressure-control instrument installed on the discard vapor line of the second column.

Reflux production and overhead temperature control are obtained by water pumped by a 7x6x7 duplex steam pump which picks up water from a 6x6x16-foot cooling tower. The cool water passes to the enclosed tube bundle of the second column to control the overhead temperature so that a maximum production of C_4 hydrocarbons can be obtained from the pressure distillate overhead discard. The cooling water flows next to the inside tube bundle of the pressure-distillate stabilizer, controlled by a by-pass which enables any amount of the cooling water to be diverted from the pressure-distillate reflux tube bundle. These water lines pass from the ground to the top of the C_4 column, then down to operating height, and back to the top of the pressure distillate column for convenience in operating and nicety of control.

Fractionated C_4 is released from the base of the second, or 20-inch column through a liquid-level controller allowing the product to flow through a commodity cooler before entering storage.

The discard of the second column is made up principally of propane and lighter fractions from the cracking plant. This discard is allowed to flow as vapor from the top of the column and mixed eventually with other gases which are used as fuel. No attempt is being made to separate iso from normal butane, as this would require additional equipment, but analysis of the overhead from the second column indicates that no appreciable amounts of valuable fractions are lost because of inefficient fractionation.

Maintaining Required Clearances In Centrifugal Pumps

ELTON STERRETT

INCREASED throughput, lessened supervision, and all to often disregard of strainers, filters and other equipment designed to relieve the centrifugal pump of the abrasive effect of grit, sand and minute particles of rust all tend to erode the pump parts even more rapidly than during peacetime operation, and thus to send the overloaded pumping equipment to the shop—or scrap pile—long bofore its useful life is out, or much-needed replacement is available.

On centrifugal pumps, especially of the multi-stage type, a unit may appear to be turning up to full load; check on the electric motor or other drive may show it putting out its usual or calculated horsepower—with only a relatively slight increase in the normal temperature of the pump body to show that it is expending most of its power in recirculation. The fluid fails to attain pressure sufficient to move on into the line, being instead forced through the enlarged clearance spaces and again picked up as suction.

The wear in a centrifugal pump which affects the output of the unit is not, except where the unit is handling a fluid in which there is considerable grit or abrasive, located in the impeller or runner, but instead occurs in the clearances between static and rotating portions of the design on the suction side of each stage. This clearance is between surfaces of greater diameter than obtained on the other side of the impeller, due to the fact that sufficient port aperture must be left around the shaft to permit the fluid from one stage to enter axially and thus be boosted to the discharge pressure of the next stage. Except in a few designs, the clearance between that portion of the impeller which forms the outer wall of the suction tube and that of the adjoining portion of the pump case is not itself a portion of the case, due to difficulty of manufacture and need for providing a surface of high abrasion resistance, whereas the characteristic most desired in the pump body is close-grained resistance against the pressures generated.

A wear-or packing-ring, usually of the same material as the impellers, usually is fitted to a recess within the pump body, with clearance as designed between the inner face of this ring and the closure portion of the impeller body. Of relatively small section, this ring is subjected only to compression in its seat, and must offer only such clearance as is demanded by running characteristics of the pump, as added clearance at that point permits the recirculation of pressured fluid and accelerated wear between the closely placed metal faces.

Examination of typical wearing surfaces of impeller and wear- or pack-ring shows that fluid has eroded both in a curve which affords excessive clear-

The eroded portion of the impeller, after being trued up and a roughing cut taken in the lathe, has been sprayed by metal of the proper analysis until worn surfaces are now out beyond the diameters required when turned or ground to afford the required clearance with the wear-ring enclosing the suction tube end of the casting.

ance at both outer edge of ring and opposite surface of the impeller casting. After operation to the point where noticeable drop in throughput is observable, the clearance at the two edges of the presumedly mating pieces of the unit will be found to be four or more times that still observable in the center of the swept area. This wear, in itself a result of fluid flow, tends further to aggravate itself if not hindered, by the scouring action set up by passage of high-pressure liquid through an aperture formed of two curved surfaces, oppositely faced.

Repair of such a pump was, until recently, one of replacement of the worn parts so as to re-establish the desired clearances and enable the unit again to put up designed pressure. With delay in obtaining replacements interposing an ever-increasing factor in unit operation, and the inability of many companies to secure men capable of fitting such replacements into the old pumps, production frequently was seriously disrupted pending overhaul or replacement of the worn pump.

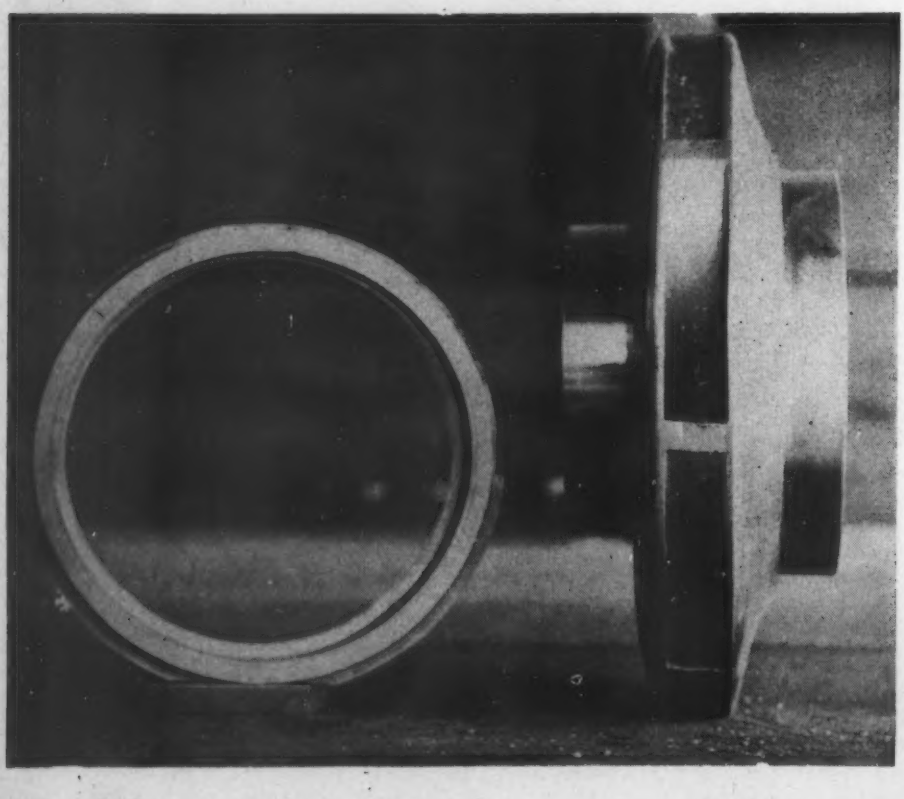
Metallizing of such units, in which the parent metal of the impeller can be reproduced exactly with the sprayed overlay, permits such a pump to be reconditioned with much less loss of production than is now occasioned by the difficulty of obtaining replacement parts. Since the wear-ring is of relatively slight section, but has sufficient metal across the wearing face to permit a reboring for two or more reworkings of the pump, standard practice is to reface the clearance surface of the ring—outer diameter being held tightly within pump case and not subject to erosion—by truing carefully in a lathe and taking light cuts across the sealing face until it has been brought back to original surface specifications, except that the diameter must be greater than originally designed by the amount of metal abraded in service and removed by the tool to recondition properly.

The metal which is taken from within the packing surface of the wear-ring is added to that required to bring the corresponding surface of the impeller back to size. Not only must the metallizer add material to care for adequate turning, grinding or other dressing of the built-up surface to restore original diameters, the work must be extended to the point where the newly finished outer face of the suction tube of the impeller be of the proper diameter to fit with minimum desired clearance tolerance within the expanded wear-ring.

Such rebuilding of the impeller section, especially in cases where the overhaul has been put off so long that the worn surface tends toward the egg-shaped, may require truing the impeller in the lathe and running a roughing cut over the surface to be built-up, it being necessary that the metal applied be sprayed onto a surface which is similar to or parallel with that desired in the finished product. That is, it is poor economy and poorer practice to expect the metallizer to build up points of excessive wear, alternating thick and thin overlays of the sprayed metal. A much better bond can be obtained, metal waste reduced, and the next reconditioning put further into the future, by time and care spent in obtaining a true surface upon which the new metal may be placed.

Where the overlay is of sufficient depth, two or more trips over the surface with the spray gun are found to afford a much more firmly knit surface than the one left by a single pass which attempts to build up a thick coating of new material. Using any of the materials normally found in oil-country centrifugal pumps, the undressed surface left by an evenly applied and thin coating of virgin material will form a satisfactory matrix for a second coat. Bond between two such coatings is ample to withstand the tearing action of the lathe tool when reducing to desired diameter, while the relatively fibrous structure of the new material affords a labyrinth within which is held sufficient lubricant to insure surface safeguarding over the initial run.

The limit to such rebuildings is reached when the wear-ring has been turned out to the point where it no longer has sufficient wall strength to retain its form under operating conditions—replacement of an oversize ring frequently enabling the impeller to be serviced for additional reworkings until or unless the erosive action of the fluid being handled has so altered the internal characteristics of the impeller that it will no longer perform as designed.



This wear-ring, on the left, has been centered in the lathe and the inner or packing face trued up until it will again give proper running clearance when set into the casing to work in conjunction with the newly refinished suction end of the impeller at its right. The other side of the impeller, faced to fit closely within the packing recess of the pump case, has sustained much less wear than the ring of larger diameter opposite it.

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Progress of the Liquefied Petroleum Gas Industry In 1943

G. G. OBERFELL
Vice President in Charge of Research
Phillips Petroleum Company

MARKETED production of liquefied petroleum gases for fuel and miscellaneous purposes is estimated to have increased 19 percent in 1943 over 1942 to 635,000,000 gallons. This estimated increase of 102,600,000 gallons is made on a different basis than in this author's previous annual reviews. Details of the estimate are shown in Table 1. Changes in the industry made it appear desirable to modify former methods of reporting marketed consumption. Heretofore estimates included LPG used in chemical manufacturing only when delivered in liquid form. Deliveries in gaseous form by pipe line from oil refineries and natural gasoline plants were not reported. This year all LPG used in chemical manufacturing has been eliminated from the estimates.

In 1942 the chemical manufacturing industry used 53,038,000 gallons of LPG delivered in liquid form by tank truck and tank car. Chemical manufacturers also processed large volumes of gaseous hydrocarbons in the LPG range delivered by pipe line from refineries and gasoline plants. In 1943 there was an unusually large increase in consumption of LPG by chemical plants. Estimation of the amount used, however, is made difficult by duplications arising from inter-plant movement for partial processing. Publication of data regarding some phases of chemical utilization of LPG probably would be undesirable during wartime.

In general it may be said that rubber and aviation gasoline consumed rapidly increasing quantities of butanes and propane, particularly in the last half of 1943. Twelve butadiene plants charging butane and butylene were completed and placed in operation in 1943. Synthetic-rubber output increased more than tenfold between the first and fourth quarters, from 10,486 tons[1] in the first

quarter to 123,300 tons in the fourth quarter. As previously stated LPG use by these plants is not included in the present estimate. Concurrent with the building of synthetic-rubber plants the oil industry has been building aviation-gasoline plants requiring butane and butylenes. Insomerization of normal butane for subsequent alkylation with butylenes caused the diversion of a large quantity of butanes from other uses.

For several years the relative volume of propane sold for LPG purposes has increased and the relative volume of butane has decreased. In 1943 this trend was accentuated. Industrial consumers used products containing a larger percentage of propane or switched from butane to propane where propane tankage was available. In a few instances 80-pound storage was replaced by 200-pound-working-pressure storage at industrial plants to permit conversion from butane to propane.

Although new domestic installations were subject to government approval a considerable number were made in 1943. Defense housing projects accounted for many new individual consumers. Government approval was given also to conversion of gas appliances to liquefied gas when consumers moved away from gas lines. New installations were approved in areas where no other fuel was readily available.

Domestic installations at the close of 1943 are estimated to total 1,900,000. This is an increase of 75,000 over last year's estimate. Part of the increase was due to correction of the previous estimate and part to new installations. About 5000 new buried-tank installations were made in the South. In Oklahoma, for example, 700 new installations were inspected by the State Fire Marshal in the first 10 months.

Use of liquefied petroleum gases by public utilities for gas manufacturing continued to increase at the rate of about 24 percent per year. Gas utilities have been confronted with unprecedented demand from war industries and domestic consumers. On the Pacific Coast gas utilities increased their purchases of liquefied gases 10 percent in addition to the 70 percent increase the previous year. In the Middle West one utility recently installed two diluters having an output of 5,000,000 cubic feet of propane-air gas per day. The same company also is mixing propane with water gas for underfiring a battery of four coke ovens and is enriching water gas for general distribution. This one company proposes to use five to seven million gallons of propane in 1944.

Natural gas distributors experienced shortages during the past winter at peak-load periods. Where natural gas was short the cause, in most cases, was

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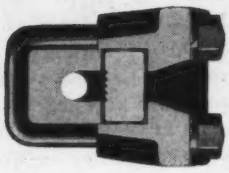

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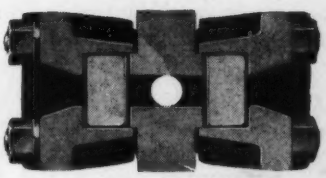

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lack of adequate long distance lines or line breakage rather than an actual shortage of gas. One result of last winter's gas shortage was the demand for a considerable number of propane stand-by installations. Two large military camps in Oklahoma now served with natural gas installed stand-bys in recent months. One of these plants has storage capacity for 100,000 gallons of propane and another has 50,000 gallons, 10 days' supply in each case.

When steel once more is freely available it is expected that there will be a considerable increase in the use of propane or butane for cold carburetion. Plans are known to be afoot for conversion of a number of town gas plants from manufactured gas to butane-air or propane-air or undiluted propane after the war.

Greater diversion of butanes to aviation gasoline and rubber encouraged refiners in a number of instances to use propane as a gasoline blending agent to obtain sufficient volatility. Experiments have shown that up to about 3 percent propane may be blended with motor gasoline to give good starting characteristics where butane supplies are deficient.

Industrial consumption of LPG suffered a brief slump early in 1943. The upward curve of demand was resumed after a short delay as activity increased, particularly at aircraft sub-assembly and parts manufacturing plants and shipyards.

The shipbuilding industry is an outstanding example of the use of liquefied gases to speed war work. It has been said by shipbuilders that propane has done more than any other product to speed the fabrication of ships. Propane has been used to augment and in many places to supplant acetylene for metal-cutting operations. With oxy-propane torches cutting speed has been increased materially. The kerf is much smoother and thus does not require a grinding operation. The amount of slag to be removed is negligible. As an example of how this type of use has increased LPG demand, shipyards supplied by one company increased their propane consumption 53 percent in 1943 over 1942 which was, in turn, 170 percent greater than 1941.

In other operations replacement of fuel oil with liquefied gases has speeded preheating of plates and pipes for bending. With propane it is possible to keep work clean by eliminating carbon deposit and localizing heat. This is particularly true in Van Stoning operations. Other applications where propane has helped improve working conditions and reduce heating time include core baking, lead melting, forging small parts, submerged combustion in pickling baths, rivet heating, rivet washing, die casing operations, and many types of heat treating.

Many of the increases in demand on the liquefied gas industry this past year were caused by the war but are not, strictly speaking solely war demand. The glass industry is an example. The shortage of tinplate has diverted a great deal of packaging of food from metal to glass. In 1943 the glass industry manufactured about 13.4 billion[2] containers compared with 11.5 billion in 1942 and 8.0 billion in 1941. The glass industry is manufacturing millions of bottles for direct war consumption such as blood plasma containers, medicine bottles, etc.

Eight typical glass manufacturing companies had a pre-war annual consumption of 770,000 gallons of liquefied petroleum gases. For the past two years these eight companies have consumed 2,975,000 gallons per year. The companies in question were not converted from other fuels to liquefied gases so the increase largely reflects the expanded production.

Transportation has been a major problem of the industry in 1943. Additions to the fleet of pressure cars included 431 new propane cars, 110 new butane cars and 183 natural-gasoline cars modified to permit transportation of butanes. Many of these new and modified cars were not delivered until late in the year. The industry could have supplied additional quantities to utilities and other industries had it not been necessary also to provide transportation for large volumes of butane, butylenes and isobutane for the aviation-gasoline program.

As the year progressed it was necessary to move ever increasing amounts of isobutane from natural gasoline plants to oil refineries for alkylation. Normal butane movement to isomerization plants also required pressure cars. The situation was complicated further by the lack of balance within the refining industry on the production of so-called B-B (butane-butylene) cuts. It was not possible to match butylene production with alkylation capacity at every point. One result was the necessity to ship butane-butylene mixtures from one refinery to another.

Two government directives designed to aid the war imposed an additional burden on the liquefied petroleum gas industry in the last quarter. Directive 75 requiring all butanes containing as much as 20 percent isobutane to be shipped to fractionating plants for separation of isomers reduced the total supply of butane available for conventional purposes and put an added strain on transportation facilities. The necessity for greater inter-refinery movement of B-B cuts caused the government to request all owners or operators of pressure cars to put 5 percent of their fleets into this refinery service. Most owners already were devoting large numbers of their cars to aviation service. By a super-human effort the industry kept most customers from running completely out of LPG although shipments in some cases were delayed.

Trucking operations of the industry

TABLE 1

Marketed Production of Liquefied Petroleum Gas

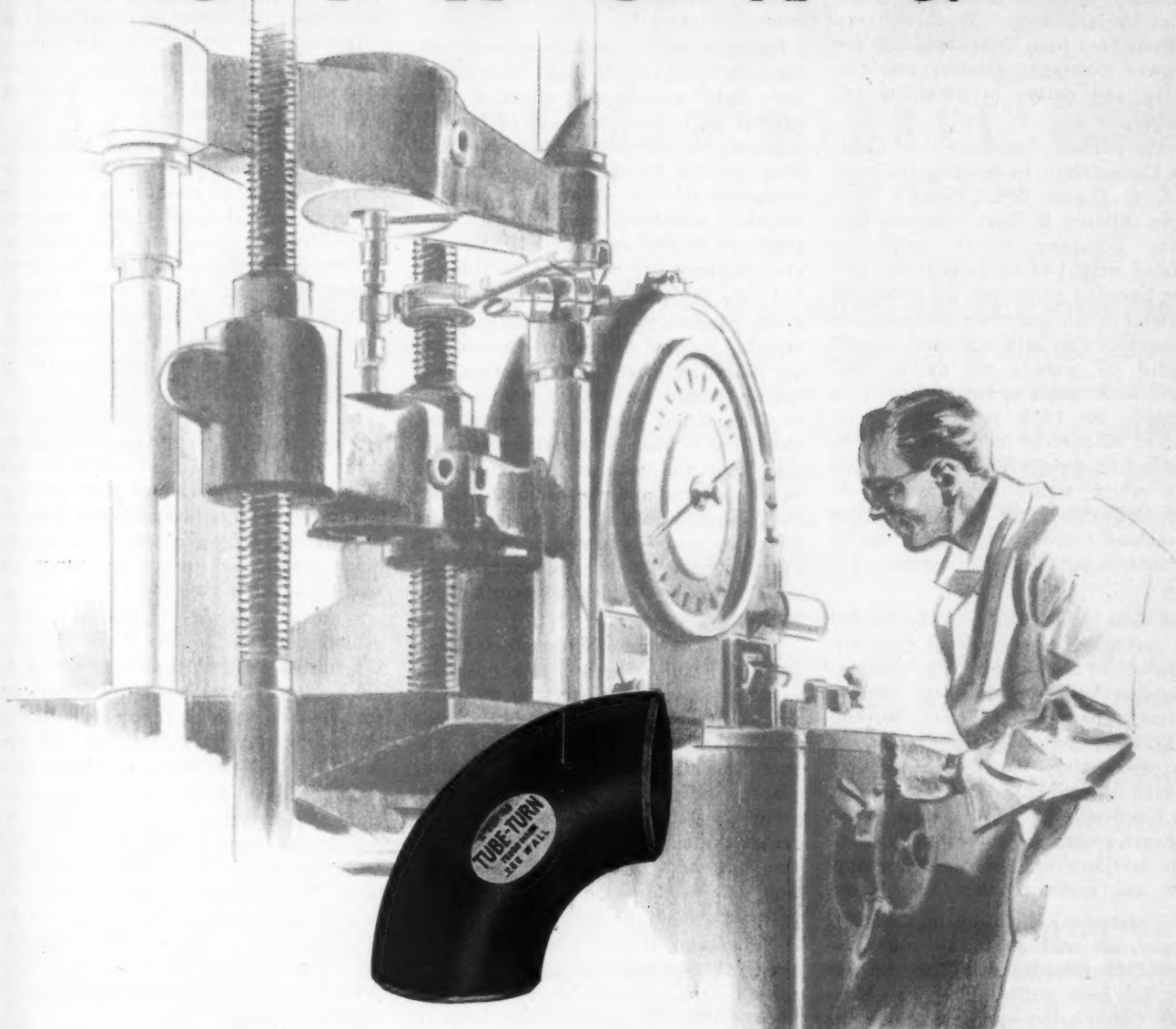
YEAR	TOTAL SALES		DISTRIBUTION—Gallons Per Year					
	Gallons Per Year	Percent Increase Over Previous Year	Domestic	Percent Increase Over Previous Year	Industrial and Miscellaneous	Percent Increase Over Previous Year	Gas Manufacturing	Percent Increase Over Previous Year
1922	222,641	....						
1923	276,863	24.4						
1924	376,488	36.0						
1925	403,674	7.2	Sale of liquefied petroleum gas confined primarily to bottled gas business prior to 1928.					
1926	465,085	15.2						
1927	1,091,005	134.6						
1928	4,522,899	314.6	2,600,000	....	400,000	....	1,500,000	....
1929	9,930,964	119.6	5,900,000	126.9	1,500,000	275.0	2,500,000	66.7
1930	18,017,347	81.4	11,800,000	100.0	2,200,000	46.7	4,000,000	60.0
1931	28,769,576	59.7	15,294,648	29.6	7,171,686	226.0	6,303,242	57.6
1932	34,114,767	18.6	16,244,103	6.2	8,167,194	13.9	9,703,470	53.9
1933	38,931,008	14.1	16,625,588	2.3	13,987,095	71.3	8,318,325	—14.3
1934	56,427,000	44.9	17,681,000	6.3	32,448,000	132.0	6,298,000	—24.3
1935	76,855,000	36.2	21,380,000	20.9	47,894,000	47.6	7,581,000	20.4
1936	106,652,000	38.8	30,014,000	40.4	67,267,000	40.4	9,371,000	23.6
1937	141,400,000	32.6	40,823,000	36.0	89,402,000	32.9	11,175,000	19.3
1938	165,201,000	16.8	57,832,000	41.7	94,983,000	6.2	12,386,000	10.8
1939	223,580,000	35.3	87,530,000	51.4	120,615,000	27.0	15,435,000	24.6
1940	313,456,000	40.2	134,018,000	53.1	159,153,000	32.0	20,285,000	31.4
1941	462,852,000	47.7	220,722,000	64.7	216,875,000	36.3	25,255,000	24.5
1942	532,402,000*	27.2*	299,559,000*	35.7	201,477,000*	16.7*	31,366,000	24.2
1943	635,000,000†	19.3	350,000,000	16.8	246,000,000	22.1	39,000,000	24.3

* Not including 52,904,000 gallons used for chemical manufacturing.

† Chemical manufacturing consumption not included.

Remarks: In the above table "Total Sales" for all years except 1943 were obtained from U.S. Bureau of Mines reports. "Distribution" for the years 1931 to 1942, inclusive, was obtained from the same source. All other volumes are estimated by the writer. The total sales volume includes all liquefied petroleum gases (propane, butane, and propane-butane mixtures) when sold as such. It includes the sale of pentane when sold for any purpose other than motor fuel blending. It does not include butane when blended with heavier petroleum fractions for motor fuel purposes. Inter-company sales transactions, such as purchases of liquefied petroleum gases by one company from other companies and then resold as liquefied petroleum gases, have been eliminated in order to avoid duplication of sales figures. The data do not reflect sales of liquefied petroleum gases used directly by the producer at the point of production, for fuel, polymerisation, solvent de-waxing, etc. Neither do the figures include sales of hydrocarbons to chemical plants or to plants manufacturing synthetic rubber or aviation gasoline or their components.

STRONG



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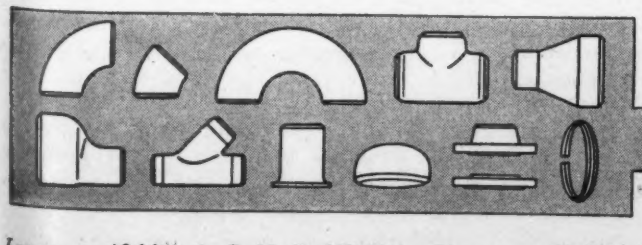

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have been increased both for transfer of B-B cuts between refineries and for deliveries of LPG to war plants and domestic consumers. Many manufacturers who formerly used tank cars are delivering 40 to 60 percent of their product by tank truck. Truck delivery operations have been complicated by the manpower shortage, gasoline and tire rationing and delays in obtaining repair parts.

In May, 1943, the Interstate Commerce Commission, in deciding the issue in I. C. C. Docket 28663, Green's Fuel, Inc., vs. Atlanta & Saint Andrews Bay Railway Company, et al, found the estimated weight of 6.6 pounds per gallon on liquefied petroleum gas from the Southwest to the Southeast unreasonable to the extent that such estimated weight exceeded 4.7 pounds per gallon. Rail carriers filed tariffs to become effective November 30, 1943, reflecting an increase of 40 percent in rates subject to an estimated weight of 4.7 pounds per gallon which would have resulted in substantially the same per-car charges as previously prevailed by the use of estimated weight of 6.6 pounds per gallon.

The Commission, in I. & S. Docket 5271, suspended the increased rates but the estimated weight of 4.7 pounds per gallon has been permitted to become effective. Therefore, effective November 30, 1943, the per-gallon charge will be approximately one third less than prevailed prior to that date on shipments from Southwestern origin points to the Southeast, embracing substantially destination territory east of the Mississippi River and south of the Ohio River.

The manpower situation in the LPG industry, as well as in all other industries considered essential to the war effort, has been critical. The War Manpower Commission has recognized the industry as being essential, resulting in some technical and key employees being granted occupational deferments for limited periods. However, the loss of men to the military services has been large and the ingenuity of management has been taxed to the limit in not only maintaining necessary services but increasing many of them where required in order to assist in prosecuting the war.

To cooperate with the government in the complete utilization of all available manpower, the industry has ceased all retail sales activities for the duration of the war. Service work has been reduced to a minimum. Management has taken extreme care, by thorough planning and giving close attention to details, to effect consumer deliveries in such a manner that manpower as well as tires and motor fuels can be saved and the necessity for vehicle repairs reduced to an absolute minimum. Women are being used extensively in jobs normally held by men. In some instances both office and field labor, as well as supplies and equipment, have been saved by billing retail domestic accounts every two months instead of the more frequent peacetime intervals.

Results of the various plans and methods adopted to save manpower have been surprisingly effective. The number of employees required by one company to carry on operations has been reduced 44 percent in 1943 when compared to 1941. Average gallons of liquefied petroleum gas delivered per employee in 1943 increased 123 percent over delivery per employee in 1941.

At the close of 1943, the industry is in the position of further "tightening its belt" in the face of greater demands by the War Manpower Commission for men for the armed services. A continuation of job studies, proper placement and utilization of the highest skills of available men and women, in conjunction with intelligent and conscientious leadership, should make it possible for the industry to not only maintain its position but to make further advances under what might be termed adverse circumstances.

Ten new natural gasoline plants begun since the war were put into operation in 1943 to increase materially the available supply of liquefied petroleum gases. Production was increased also by substantial additions to previously existing plants. Butane fractionating columns were installed where possible to increase the supply of isobutane for aviation gasoline manufacture. Refrigeration was added at some plants to improve efficiency of extraction.

Texas and Illinois added more new production of liquefied gases than any other state. Illinois production rose about 50,000,000 gallons. Three large recycle plants in Texas added materially to motor-fuel supplies as well as to production of isobutane, normal butane and propane. Two plants were built in Arkansas for the primary purpose of sulfur removal from sour natural gas to be used as fuel for war plants. Both plants are producing large quantities of liquefied gases as by-products.

To aid the war program one Texas manufacturer tied a group of old gasoline plants together by pipe line into a central treater where isobutane was recovered in addition to normal butane and propane. Previously mixtures had been produced at some of the small plants in the system but the project largely increased the production of LPG for fuel as well as for aviation gasoline synthesis.

Another manufacturer increased production of LPG with a minimum utilization of steel by passing natural gas through absorbers in the field and circulating the rich oil to a gasoline plant several miles away where still and fractionation capacity was available for recovering the LPG and natural gasoline. At the year's end an Illinois manufacturer was producing raw gasoline at a simplified plant using minimum quantities of steel and transporting the raw product to an older natural gasoline plant for fractionation.

Oil refiners have increased recoveries of LPG at many points although little of this increase in production is finding its way into normal LPG markets. Virtually all is being used in the manufacture of aviation gasoline or synthetic rubber. A recent report of the Bureau of Mines stated that use of liquefied refinery gases for fuel purposes decreased 30 percent in the first nine months of 1943.

East Coast refiners have made more propane this year than last since their crude oil supplies have increased through operations of the big-inch pipe line and larger crude imports by tanker. Butanes manufactured by Eastern refiners are being used almost exclusively for motor fuel or aviation gasoline.

Industry Advisory Committees were established in the five PAW districts by Administrator Harold L. Ickes to advise the Petroleum Administration for War on various problems affecting the production, transportation and distribution of liquefied petroleum gases.

The Liquefied Petroleum Gas Association has continued to play an active role in the industry. Transportation and technical committees were particularly busy. The Technical and Standards Committee proposed revisions in National Board of Fire Underwriters Pamphlet 58 to provide rules for warehousing LPG cylinders and to clarify previous regulations.

State regulations and taxation measures affecting the industry were considered by legislatures in Kansas, New Mexico, Nebraska, New York, Minnesota, Wisconsin, Massachusetts, Arkansas, Georgia, Colorado, Texas and the District of Columbia. Action was taken affecting distribution in Arkansas, Georgia, Colorado, District of Columbia and Texas.

Considering wartime conditions the liquefied petroleum gas industry has served its domestic customers and war industries well. The year 1944 is expected to be a critical year for the industry with serious problems of manpower, transportation and supply to be solved.

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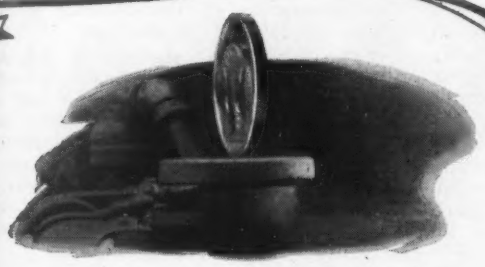
[2] Press release of Glass Container Institute.

CONVERTED

ENGINE TO PORTABLE DIESEL



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PIWC Stresses Free Enterprise in Worldwide Oil Development

PRIVATE enterprise as the mainspring of foreign oil development came to the fore in deliberations of the Petroleum Industry War Council in its December sessions. The council passed a resolution in opposition to the entry of the government into foreign oil development through Petroleum Reserves Corporation. Its foreign operations committee had submitted a lengthy report in support of the advisability of maintaining private enterprise.

The meeting was significant in that Harold L. Ickes, Petroleum Administrator for War, had spent several hours with PIWC while he outlined the policies of Petroleum Reserves Corporation and answered questions that came out of an article he had prepared for a national magazine.

The resolution stated:

"The United States government should under no circumstances acquire title or ownership or directly or indirectly engage in foreign oil exploration, development or operation," but "should extend to our nationals operating in foreign countries the encouragement and effective assistance of the American government in their foreign oil exploration, development or operation."

The position of the council was based on this proposition:

"In recognition of the fact that private capital and competitive enterprise have developed and will continue to develop vast foreign oil reserves as well as a great domestic oil industry which constitute a great and indispensable bulwark for national defense," the resolution stated, "and whereas the immediate war necessity and the continuing necessity for the acquisition, exploration and development of foreign oil reserves by our nationals should be afforded all possible diplomatic protection in foreign lands, a foreign oil policy of the United States should have the support of the American people as well as the support of the American oil industry."

In its report on the basis for world oil development through free enterprise the Foreign Operations Committee of PIWC suggested formation of a compact among nations, similar in form and functions to the Interstate Oil Compact Commission.

Four major reasons why private enterprise can best deal with the problem were given in the report, which pointed out that:

"(a) Private operations reduce the political dangers inherent in the international field;

"(b) Private enterprise is the best source of the venture capital required for the undertaking;

"(c) Private enterprise can best supply and develop the requisite managerial and engineering techniques;

"(d) Oil operations involve exploration, production, transportation, refining and distribution. Governments entering the oil business in one area will soon find themselves extended, directly and indirectly, into a far-flung complex of international complications transcending the original locus."

The report pointed out that the whole picture of the American oil situation has altered as a result of the war, which has materially hastened the day when the United States moves over from an export to an import basis.

"Today," it was declared, "as a result of world developments, the United States has an inherent interest in the assurance of peace and economic stability in the postwar world" and "oil developments abroad are of critical importance in the foreign policy of the United States."

"Long an oil exporter on balance," the committee said, "the United States may face a significant change in its status. Evidence points to the imminence of a shift from a condition in which this country has surplus oil for export to one in which the nation will become a net importer of oil. This expected change will make the economy of the United States partly dependent upon foreign oil resources."

The very national security of the country is dependent upon adequate world oil developments, it was asserted, and the government "can benefit all peoples by encouraging the energy of private enterprise in world oil developments."

"The proficiency of the petroleum industry of the United States is an invaluable agent for promoting postwar reconstruction and industrial advancement throughout the world," the committee added.

The report pointed out that the five regions which contain an overwhelming proportion of the world's oil are the United States, the Soviet Union, the Middle East, the Far East and the Caribbean area. The Middle East and the Caribbean area together probably contain more known oil than the rest of the world, it commented.

"The international oil problem is of such major dimensions that the government of the United States should not only take action with respect to promoting the interests of its own nationals, but should also assume leadership in assuring the collaboration of other nations and the coordination of oil policies among nations, the committee said.

The prosperity and security of the world require the efficient and orderly development of its oil resources, it argued, explaining that:

"Efficient and orderly development involves the application of advanced engineering practices, and especially the implementation of the concept of the optimum rate of production.

"The universal application of the optimum-rate principle will result in the development of surplus producing capacity available in case of emergency. Its advantages have been fully demonstrated in the United States where it is proving invaluable during the war. It is a fortunate, although fortuitous, circumstance that the principle is equally advantageous in peace and war.

"Efficient and orderly development requires that the producing capacities of the various sources of supply be balanced with the needs for oil.

"Efficient and orderly development requires a clear definition of the respective roles of private enterprise and governments; dependability of contracts; non-interference with operating procedures once proper rules are set; and equal opportunity among competitors.

"Efficient and orderly development is possible only if contracts are respected by the parties to them, and if means are available for prompt and equitable solution of disputes arising under them.

"The national oil policy of the United States should aim at securing for American nationals access to the world's oil resources on equal terms with the nationals of all other countries."

Of the three possible methods for developing the oil resources of the world—government operations, private enterprise, and mixed operations—private enterprise is the surest and soundest choice, it was held.

The reasons for this conclusion were summarized as follows:

"Private American enterprise has already demonstrated its ability in international oil developments.

"To enhance national security, many and widely distributed sources of products for military supply should be in the hands of United States nationals. Such sources have been developed by private industry and in many areas can only be so developed. Only through distributing facilities as well as sources of supply can these requirements be assured.

"Many countries not only resent but prohibit by law the holding of natural resources by alien government either directly or indirectly, while permitting private capital to operate freely. Government enterprise may thus prove a handicap in time of war, as recent experience has demonstrated.

"Any direct participation by the government of the United States in foreign oil operations, whether alone or in partnership with private corporations,

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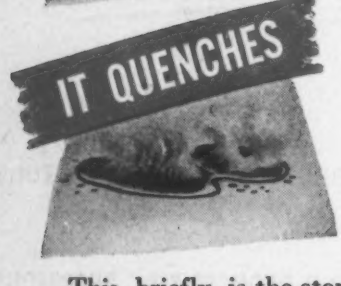

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will discourage private enterprise; and will not only increase the political complications but will retard the orderly development of the world's oil resources.

"The scope of foreign oil developments has been restricted by the large number of risks involved. Some of these risks are common to oil exploration and development in general, but in addition there are special risks arising from conflicting national policies endangering the continuity of operations. Within the United States the latter category of risks is absent and in consequence oil discovery has been immeasurably enhanced by the multiple efforts of great numbers of operating units, similarly. These benefits can be gained for foreign operations by measures making for increased stability. The government of the United States can serve the interests of a greater number of its own nationals and at the same time promote the interests of foreign countries by means of a foreign oil policy designed to reduce the political risks inherent in foreign oil operations.

"In the period of transition from war to peace, questions will arise as to the disposition of oil facilities abroad which the government of the United States has acquired in the course of the war. In general such facilities should be disposed of to private enterprise.

"During the war the Allied nations have built a great many facilities for handling oil products in the war, consisting of bulk storage, seaport installations and airports—particularly in the Eastern hemisphere. When these facilities are no longer needed for war they should be disposed of in such a way as to insure of fair and equitable participation therein by American companies in the world's oil trade."

A foreign oil policy must be established at once if the interests of the country are not to be sacrificed, it was insisted.

The combined domestic and foreign oil reserves held by United States nationals constitute a smaller proportion of the world's reserves than the ratio of our consumption of oil to total world consumption, it was pointed out, and action is needed to enlarge the reserves under the stewardship of our nationals and to encourage the retention of existing contracts.

"Nationals of the United States should not be in a position of inferiority in acquiring and developing petroleum reserves within the territories or spheres of influence of other nations," it was warned.

The essentials of an immediate foreign oil policy, as outlined in the report, are:

"(a) The American petroleum industry should be encouraged to expand its plans for developing the world's oil resources. This encouragement requires assurance that nationals of the United States will receive the cooperation of our government in securing a position of equal opportunity with the nationals of other countries and that the government itself will not enter into competition with its own nationals.

"(b) Existing handicaps in the oil operations of our nationals abroad should be examined in the light of their incidence upon our national welfare, and efforts should be made to remove such handicaps as originate in the laws and practices of the United States. American nationals operating abroad must be able to comply with the laws and cus-

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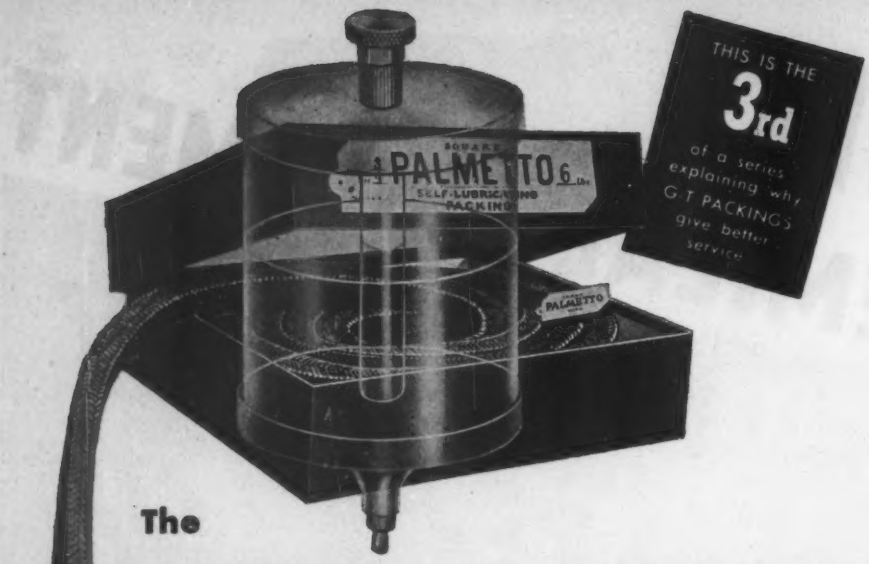

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toms of foreign countries without incurring the risk of violating American laws.

"(c) The diplomatic support accorded to our nationals by the government of the United States should be as effective as that accorded to nationals of other countries by their respective governments.

"(d) The ultimate disposition of oil facilities and supplies developed or paid for abroad by the government of the United States in the course of the war should be so designed as to promote the interests of our nationals in the post-war world.

"(e) Our foreign oil policy should also include appropriate measures for the return after hostilities of American-owned properties, rights and interests in Axis-held territory; adequate compensation for assets destroyed and damaged; and assurance of an early commercial operation of returned properties."

It was also held that the industry should be admitted more fully into the policy councils of the government, and its ideas and experience used in a consultative capacity in all policies and measures affecting the future status of foreign oil operations, and a committee of men with suitable experience in foreign operations be set up to maintain a continuing consultative connection with the oil-policy-making departments of the government.

Special cooperation with Great Britain is suggested on the ground that a large part of the known reserves involved in international trade are owned, controlled or under concessions held by American and British nationals and it is desirable, therefore, that the two governments take the lead in achieving an agreement on basic principles.

The international oil compact suggested in the report should be open to adherence by all countries, producing and consuming countries alike, the committee stated. Its objective should include the equitable distribution of oil to all nations and the avoidance of national restrictions imposed as artificial aids to the production of synthetic or substitute products. The agreement should become effective upon the adherence of five countries, provided the adhering group included the United States.

"Our own Interstate Oil Compact does not oust our states from control of their own policies," the committee concluded. "Similarly each country must be left freedom with reference to its own policy.

"Within the United States, the Interstate Oil Compact assures the coordination of policies of the various states, with federal encouragement. Similarly, the oil policies of various countries need to be coordinated.

"An international oil compact is suggested as the best means of assuring international cooperation in the future."

Annual WPRA Meeting to Be Held in St. Louis

The thirty-second annual meeting of Western Petroleum Refiners Association will be held in the Jefferson Hotel, St. Louis, March 28. The program of only one day follows the precedent set following Pearl Harbor, when the usual program of three days was cancelled and the meeting restricted to a single day.

The announcement from the office of John C. Day, secretary, urged that those expecting to attend make hotel reservations well in advance.

Report on Lend-Lease Shows United States Biggest Oil User in War

PETROLEUM products valued at $608,000,000 were shipped to our fighting allies under lend-lease from March, 1941, through October, 1943, Congress was told last month by President Roosevelt.

Most of the lend-lease oil products, $423,000,000 worth, went to the United Kingdom, but Russia got $27,000,000 worth, and $61,000,000 worth went to Africa, the Middle East and the Mediterranean area, and another $97,000,000 worth went to China, India, Australia and New Zealand.

Incorporated in the report was an extensive discussion of lend-lease petroleum in the war, in which it was pointed out that the United States is actually exporting now to all countries a smaller quantity of petroleum products than was shipped abroad before the war, with about 90 percent of all the oil we produce being used for our own war industry and armed forces.

"Our allies are also making the most effective possible use of their own petroleum production and refining facilities—limited though these are as compared with our own," Congress was told. "A substantial part of the overseas petroleum requirements of the United States naval, air and ground forces, and merchant marine is supplied by our allies under reverse lend-lease.

"With the petroleum products we have sent under lend-lease we have added immeasurably to the striking power of the United Nations as a whole. The air assault from the United Kingdom on Nazi Europe, the Soviet victories over the Nazi army and the Allied campaign against Japan in the Pacific have all been greatly aided by lend-lease supplies of gasoline, oil and lubricants."

Supporting the contention that we are exporting less oil than before the war, the report cites the 1938 experience, showing a crude production of 1,214,000,000 barrels and exports of 216,000,000 barrels, or 18 percent, while for 1943 production is estimated at 1,500,000,000 barrels and all exports at 139,000,000 barrels, or 9 percent.

"As the above table shows," it was pointed out, "the additional production of crude petroleum in the United States since the outbreak of the war and the curtailment of nonessential civilian demands have not been caused by lend-lease consumption of United States petroleum products. They are the result, instead, of the large demands upon domestic petroleum production of our own war industries and of our own armed forces in this country and abroad. In fact, a substantial part of the petroleum products shown as lend-lease exports are returned to our armed forces abroad, in addition to the large quantities of petroleum products which our allies furnish our armed forces under reverse lend-lease from their own petroleum resources."

Middle East Ahead of Prewar

Meeting charges that the British have not furnished as much oil as they might from their Middle East reserves, the report declared that production in that area "has already surpassed the level of pre-war production, and current production is greatly in excess of the production of two years ago when the whole area was threatened with the danger of falling under Nazi control.

"All petroleum refining facilities in the Middle East, as elsewhere, are being utilized to the fullest extent consistent with the efficient use of tankers and the maximum output of those petroleum products that are most needed for fighting the war. For example, the great refinery at Abadan at the head of the Persian Gulf is currently operating at its top output under these conditions. This refinery, owned by a British corporation, is by far the largest refinery in the Middle East and has been the only United Nations source of aviation gasoline in that part of the world. The aviation-gasoline plant at Abadan is operating at its full capacity with its present equipment. Its output of aviation gasoline has already been more than doubled and is being further increased to several times the pre-war output by the provision of additional equipment.'

"The British government, which has had a substantial military-supply responsibility in the Middle East, has not hesitated to expand the petroleum facilities in that area," the President continued. "The first stage of the expansion of the aviation-gasoline facilities of the Abadan refinery was begun in the fall of 1941 and the expansion is continuing. The capacity of the British-controlled refinery at Haifa is also being expanded and the refinery at Suez has been operated at full capacity throughout the period of active warfare in this area. The entire expansion of aviation gasoline and basic facilities at Abadan is being paid for by the British. It has not been carried out with lend-lease funds."

Mr. Roosevelt also disclosed that a project has been undertaken to construct an aviation gasoline plant and to expand the basic facilities of the refinery at Bahrein, halfway down the Persian Gulf. This refinery is owned by United States corporations and equipment supplied from this country for the project is being paid for by the companies with the assistance of a loan from the Defense Supplies Corporation.

Reverse Lend-Lease

The United States, with minor exceptions, does not pay for products currently obtained from the Middle East, it was explained. Practically all bunker oil for our naval and merchant vessels in the Middle East is provided by the British government under reverse lend-lease, and products of all types shipped from the Middle East refineries to Australia, India, South Africa and in the Mediterranean area are furnished locally to our armed forces and merchant vessels in the same manner.

"The effective war use of the combined petroleum resources of the United Nations has been primarily determined by the supply of tankers and other forms of transportation to carry the refined petroleum products to war theaters," the report pointed out. "Many ocean and overland routes have been cut off completely and other routes are highly dangerous.

"There has been a critically short supply of tankers available to the United Nations in relation to the needed quantities of petroleum products and the long distances over which it was necessary to haul these products from the refineries to the war theatres. United States- and British-controlled tankers have been jointly programmed to maintain the most efficient operation and eliminate cross hauls. The critical shortage in tankers has made it imperative, in order to maintain the maximum supply of petroleum products going into theaters of operations, that the shortest haul be used wherever possible. In addition, the United States has thereby gained tankers for essential domestic use.

Short Haul Rules

"Ever since the beginning of lend-lease, the 'short haul' principle has governed shipments of petroleum products to the Southwest Pacific except where emergency and strategic developments have necessitated departures from that principle. Petroleum products for Eastern Australia and New Zealand have generally been supplied under lend-lease from the West Coast of the United States and Peru, because these were the shortest routes. United Nations naval, air and ground forces in Western Australia, the Indian Ocean area and the Eastern Mediterranean have depended upon supplies of petroleum products from the refineries in the Middle East. The only petroleum products customarily shipped to these areas from the United States have been products such as high-grade lubricants, which are not produced in substantial quantities outside of the United States, and aviation gasoline when the output at Abadan was not sufficient to meet all needs."

The Allied campaign in French North Africa was supplied primarily from the Western Hemisphere because this was the shortest sea route so long as the Mediterranean was closed to Allied shipping. During the coming year, however, a major part of the oil needs will

probably be supplied from British sources in the Middle East.

Shipments to England

The United Kingdom has been the war theater to which the greatest quantities of oil products are supplied under lend-lease. Tankers could not be spared to make the long voyage to the United Kingdom from the Persian Gulf refineries via the Cape of Good Hope, which is about four times as long as the route from the United States to England, or through the Mediterranean, which is about twice as long, it was explained.

Most of the products used by the Soviet forces are from Russian sources, but certain vitally needed products were not refined in sufficient quantities in the U.S.S.R. and have been supplied by the United States under lend-lease, it was stated. Several refinery units have been sent to the Soviet Union to enable Russia to increase its production of aviation gasoline and other high-grade products from its own resources, and the Soviet Union also has received products from the British by way of the difficult rail-truck-sea route from the Persian Gulf refineries.

Bigger Need in 1944

"Every effort is being made to increase the crude-oil production, the refining capacity and the supply of tankers available to the United Nations," Congress was assured. "The over-all petroleum war needs of the United Nations in 1944 will rise above what they are now as the magnitude of our offensive increases. The increasing numbers of planes, ships and tanks which we are now producing and putting into action against the enemy require increasing quantities of gasoline, oil and lubricants.

"Additional supplies of petroleum products from other areas will not therefore result in a corresponding reduction in the demands on our own petroleum resources. All available supplies of petroleum products will be required for a speedy and complete victory of the United Nations over the enemy. In the future, as in the past, the petroleum resources of each of the United Nations will be utilized in its own direct war effort and the combined war effort, in proportion to the maximum ability of each to produce and efficiently deliver the petroleum products needed in the prosecution of the war.

"After the war the nations of the world, including the United States, will require petroleum to maintain their industrialized economies. As in the case of other natural resources, some nations will have insufficient oil reserves to meet their petroleum requirements. Others will have a surplus. Agreed action by the nations of the world, in the master lend-lease agreements, for the expansion of production, the elimination of discriminatory treatment in commerce, and the reduction of trade barriers will assure the United States and other nations their fair share of the petroleum produced in all parts of the world."

North Africa

The report also answered allegations that oil shipped to French North Africa had been distributed among the natives, pointing out that the area is virtually 100 percent dependent on imports for its supply of petroleum products and that, when the country was invaded, "it was a military and lend-lease problem of the first magnitude to supply all of the oil and gasoline which was urgently needed and to restrict its use to essential military purposes."

"All petroleum products in French North Africa are, and have been, under strict military control," it was asserted. Upon arrival there, it was explained, the products are allocated by the Allied headquarters to the several military and civilian uses strictly on the basis of need, with civilian needs having the lowest priority. Under the arrangements now in effect, the French pay in dollars for all of the products delivered for civilian use.

In the first eight months of 1943, approximately 140,000 barrels of gasoline was allocated for essential civilian services in Morocco, Algeria and Tunisia, none for pleasure driving or other non-essential services, it was stated.

"On the average, the report said, "less gasoline has been provided for the few private cars permitted to operate in French North Africa for such essential purposes as doctors' calls than is permitted to A-card holders in this country. A large number of the private cars in North Africa have been requisitioned by the military authorities for the use of Allied military personnel. Since these cars in many cases are not clearly marked as military vehicles they may lead a casual observer to believe that more cars are using gasoline for civilian purposes than is the fact."

Colonial Beacon Refinery Celebrates Safety Record

When clocks of the Everett plant of Colonial Beacon Oil Company registered 7:45 p.m., December 13, 1943, a safety record of two years without an accident went into the records.

The accomplishment was celebrated the next day with a luncheon in the Hotel Statler, Boston, with an appropriate program. L. E. Ulrope, president, introduced the following speakers: Frank E. Lewis, mayor of Everett; Maurice J. Tobin, mayor of Boston; Leverett Saltonstall, governor of Massachusetts; Paul C. Shea, general manager of the Everett refinery; Howard W. Millken, president of the refinery employees association; Chester F. Smith, president of Standard Oil Company of New Jesrey; Frank W. Pierce, director of Standard Oil Company of New Jersey.

The significance of this record in safety was thus set forth in the luncheon program:

"Three times last winter the War Production Board prepared a list of Massachusetts war plants whose fuel supplies should cut off if the emergency deepened. Every oil man knows the teamwork with which the oil industry met these crises. The Everett refinery supplied its large share of the war plants of the greater Boston area. An accident which would have interrupted or stopped production would have been serious.

"Only a little more than a decade ago the Everett refinery was regarded as a hazardous place. The progress of petroleum science and technology has eliminated most of those old-time hazards. In the year ending June 30, 1943, Everett won the fifteenth annual nation-wide Petroleum Industry Safety Contest among refineries in Group B. As of 7:45 p.m., December 13, 1943, the Everett refinery completed two full years with 2,068,148 man hours of work without the loss of a single hour due to accident—a perfect record."

House Votes Higher Price for Crude Oil

An increase in the price of crude oil was approved by the House of Representatives December 13. The measure provides for a price at not less than 80 percent of parity and not more than parity. This would allow price increases of from 35 cents to 74 cents a barrel.

Approval of the increase was exceptional in that the bill was forced out of committee and passed despite efforts of administration leaders to prevent a break in the "economic hold-the-line policy."

The bill, introduced by Representative Wesley E. Disney of Oklahoma last June 7, lay unconsidered in the files of the House Banking and Currency Committee until last month, when it was blasted out by a petition to discharge the committee, signed by 218 members of the House.

Main argument for enactment of the legislation was the necessity of a better crude price to encourage exploration and production, without which, it was warned, a serious oil shortage would arise.

The opposition was based on the charge that the bill would tear down effective price control and pave the way

Petroleum Institute Plans Silver Jubilee Meeting

For its silver jubilee annual meeting the American Petroleum Institute will return to the Stevens Hotel, Chicago, November 13, 14, 15 and 16, 1944. The dates and meeting place were announced in December by William R. Boyd, president, who pointed out that the last two annual meetings had been devoted to war.

A program in keeping with the celebration of the twenty-fifth anniversary of the organization will be perfected during the year. Announcement of dates and meeting place was released with the following explanation:

"It is the hope of every oil man that the continued successes of our fighting men will make our complete victory in Europe, and oil's contribution to that victory, the main topic of the twenty-fifth annual meeting. If this hope is realized the silver anniversary meeting of the American Petroleum Institute will indeed be a jubilee. Included also in the program will be a review of the institute's quarter century of progress; an appraisal of the opportunities and responsibilities of the petroleum industry in the transition to peace; reviews by high ranking government officials and messages from leaders of American industry, and the long established conferences and committee meetings to review the scientific and technological achievements of the industry. Traditionally, too, the 1944 conclave will be the meeting ground and trading post of the petroleum industry where thousands of oil men will gather to exchange ideas, news and friendly words with one another."

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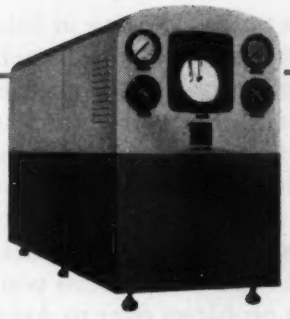

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LOS ANGELES, CALIFORNIA

for demands for increases in the prices of other commodities, wrecking the administration's hold-the-line policy.

Arguing on the point whether the House should take the measure up, Representative Brent Spencer of Kentucky, chairman of the Banking and Currency Committee, urged that his group be given an opportunity to consider the matter, rather than set an "evil precedent," and promised to hold public hearings almost immediately.

With Disney and other oil-state Congressmen opposing further delay and pointing out that the legislation has been the subject of extended discussion in the House over a period of several months, the House voted to take the bill up 247 to 71, and later, by 206 to 128, defeated a motion to have it recommitted to the committee.

The several changes that were made in the bill were designed to deal with points over which there were prospects of a determined fight. These included the proposal to wrest control of prices from OPA and place it with PAW, whch was seen as inviting a presidential veto, and Disney supported an amendment by Representative Edward H. Rees of Kansas to eliminate the provision.

Disney declared that a 35-cent increase would mean an additional cost of $2.97 a year to the average motorist, $10.06 to the average trucker, $4.96 to the average farmer and $11.93 to the average householder heating with oil.

"I have yet to hear of the consumer who wouldn't rather pay a little more for his gasoline and get it than to pay less and do without it," Disney declared.

Navy Needs Officers for Oil-Terminal Supervisors

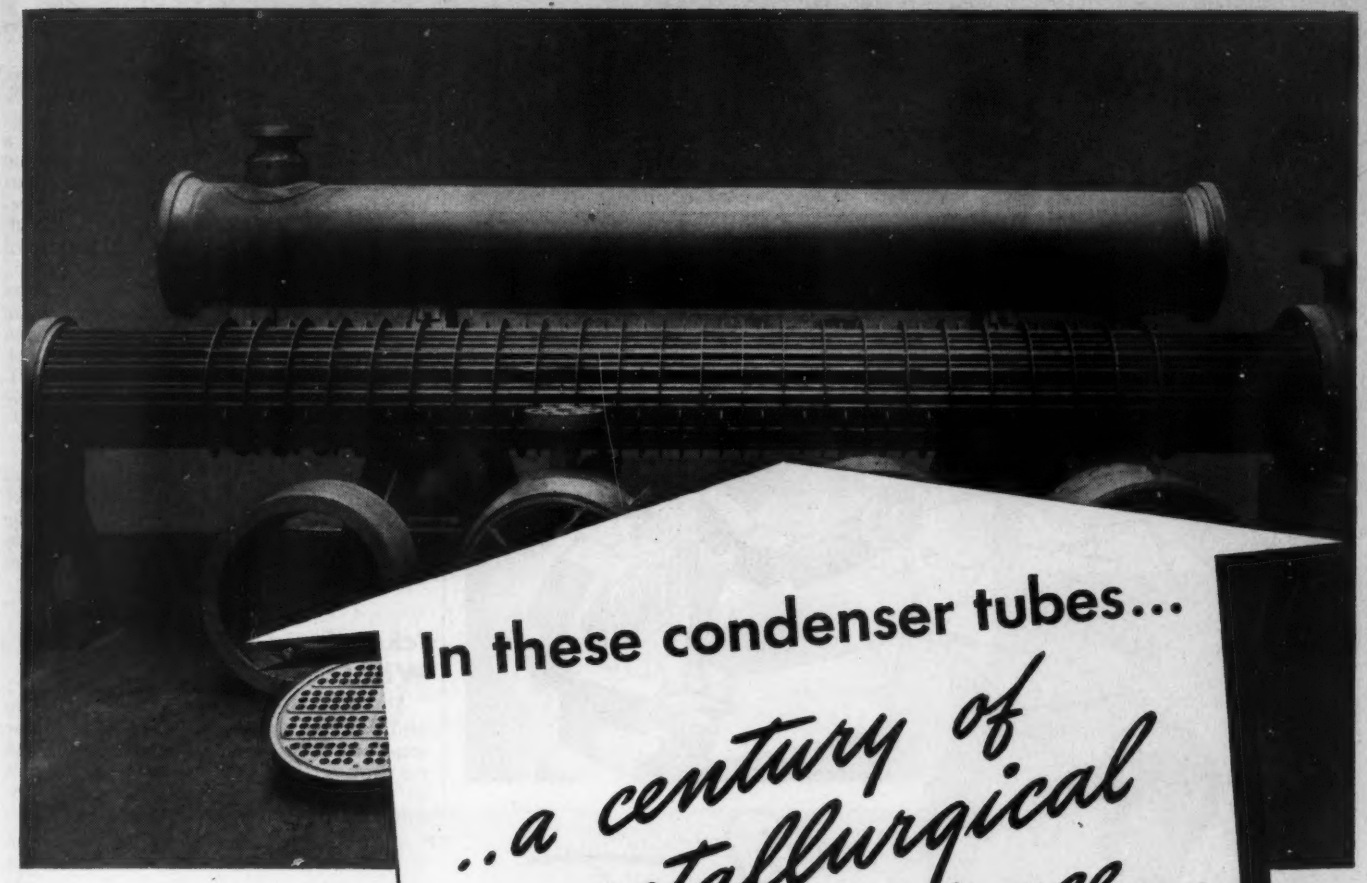
The Navy needs men who can qualify as officers in connection with a special program for oil-terminal supervisors, and has sent out a call for volunteers for such service.

Successful candidates will be commissioned and assigned duties, both within and beyond the continental limits of the United States, having to do with the handling of all types of fuel, including the loading and unloading of tankers,

Chemicals Wanted

The National Registry of Rare Chemicals, Armour Research Foundation, Illinois Institute of Technology, Chicago, Illinois, has received urgent requests for the chemicals listed below. If anyone has one or more, even if only in one gram quantities, please inform the Registry.

Butanediol-1,2
Ethylene imine (large quantities)
Mellitic acid
Methylene sulfate
Pure neopentane
Titanium hydrite (5 lbs.)
Trimethyl sulphine hydroxide
Bituminous shale oil
1-Fluoro 1-1-2 Tribromo ethane
Indium trichloride
o-phenanthroline monohydrate (ferroin)
Sodium pyruvate



In these condenser tubes...

..a century of metallurgical experience

• Anaconda Condenser Tubes are used in this oil refinery equipment made by Alco Products Division of the American Locomotive Company.

YOU can't see it, yet the experience inherent in Anaconda Tubes is one reason why many users and manufacturers of this type of equipment confer with our Engineers —specialists in Condenser and Heat Exchanger Tube problems—in making their selection of the most suitable alloy.

They know that operating conditions for condensers and heat exchangers are seldom the same. Liquids and vapors have varying degrees of corrosiveness. Working temperatures are frequently high. Corrosive chemicals are commonly added to neutralize objectionable elements. Often inadequate water supplies necessitate the use of cooling towers with the inevitably harmful air saturation.

Only by selecting well made condenser tubes of the most suitable alloy to meet a particular set of conditions can maximum value be obtained. That is why The American Brass Company, using several methods, manufactures a wide selection of alloys for Anaconda Condenser and Heat Exchanger Tubes.

BACK THE ATTACK . . . WITH AN EXTRA WAR BOND

4397

Anaconda Condenser Tubes

ANACONDA

THE AMERICAN BRASS COMPANY • General Offices: Waterbury 88, Connecticut
Subsidiary of Anaconda Copper Mining Company
In Canada: Anaconda American Brass Ltd., New Toronto, Ont.

Invite

"MONTY"*

TO YOUR POSTWAR PLANNING CONFERENCES

Having grown up with the petroleum industry, worked in many great chemical plants and studied their postwar requirements, Monty can contribute sound ideas and constructive suggestions. He knows that higher octane fuels, with consequently more powerful engines, will require improved lubricants — and Filtrol Adsorbents will make them better. His experience in catalytic cracking plants will help you blueprint other hydrocarbon end-products — and Filtrol Catalysts will produce them. So, let Monty sit in on your product-planning meetings — his counsel involves no obligation.

* *Montmorillonite structure*

FILTROL RESEARCH AND DEVELOPMENT

FILTROL CORPORATION, *General Offices*: 634 S. Spring Street, Los Angeles 14, Calif. • *Plants*: Vernon, Calif., and Jackson, Miss.

tank cars and barges and the supervision of storage facilities.

Applicants must have had at least five years' experience in the handling of bulk fuel oil and at least two years' experience in a water terminal storage plant in a supervisory capacity. Inland terminal experience unless accompanied by experience at a water terminal is not acceptable. Candidates must have a knowledge of the loading and unloading of ocean-going tankers of large capacity. At least two years of college education is desirable but outstanding business progress and experience will be given consideration in lieu thereof. It is also desirable for candidates to have a knowledge of specifications for gasoline, fuel oil, lubricants and aircraft-engine oil.

Age limit is from 30 to 50 years.

Applicants must meet Naval physical requirements and possess officer-like qualities. All applications should be made to Procurement Offices located in principal cities throughout the United States.

Ickes Says PAW Positively Will Close Up After War

PAW definitely will close up shop and go out of the oil business at the expiration of the war emergency and no thought is being given to continuance of federal control of the industry, Administrator Ickes said December 30.

Questioned as to whether his recent statement that he would work with the oil industry to restore it "so far as possible to ante-bellum competitive status" involved the possibility of continued regulation, Ickes answered with a flat "no", adding that he plans to close out PAW as soon as possible.

The administrator, however, was less direct in answering a similar question as to the future of Petroleum Reserves Corporation, saying that PRC has nothing to do with domestic oil matters and that, so far as operations abroad are concerned, "We don't know yet; that is all so inchoate that I can not say."

Streamlining PAW Part of New Year Program

The New Year found PAW in streamlined form following a shake-up which consolidated the supply and transportation divisions and expanded the marketing division to take in distribution, the two to be known probably as the "Transportation and Supply" and "Marketing and Distribution" divisions.

The changes also involved the disbanding of the supply and distribution subcommittees with appreciation to their members for the services rendered, and the re-aligning of the marketing and transportation district committees to conform to the new set-up in Washington.

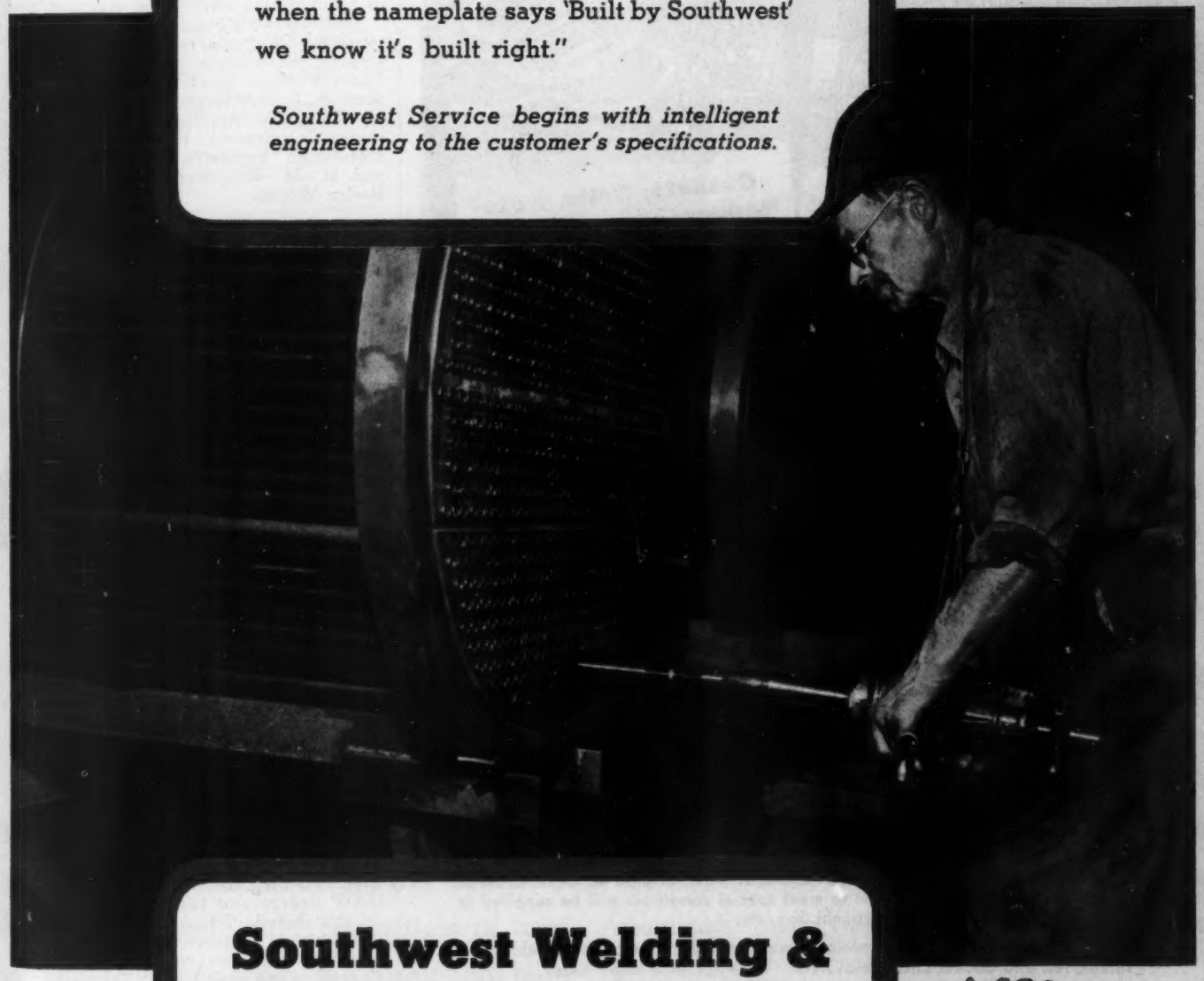
The general and affected functional committees have been asked to nominate members for the marketing and distribution and transportation and supply committees which are to be set up, keeping them, however, within the established twelve-member limitation.

As reorganized, the new marketing and distribution division and district committees will have responsibility for distribution from terminal supply points to the consumer and the transportation and supply division and committees will

BUILT BY SOUTHWEST

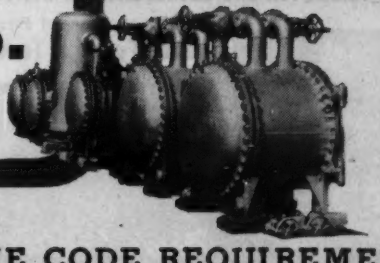
"Building refinery equipment to specifications means a lot more than just welding. Plenty of operations went into making this heat exchanger before I started to work on it—and there'll be a lot more when I'm through with it. Most of the men at Southwest have been here a long time. They know their jobs—so when the nameplate says 'Built by Southwest' we know it's built right."

Southwest Service begins with intelligent engineering to the customer's specifications.



Southwest Welding & Manufacturing Co.

ALHAMBRA, CALIFORNIA



FABRICATORS OF STEEL TO ASME AND API-ASME CODE REQUIREMENTS

Make Good Piping Better

with

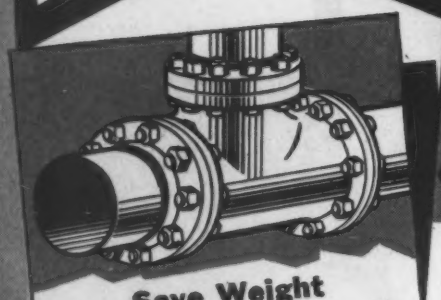
WELDOLETS • THREDOLETS

3 Types Meet Every Need

WeldOlets for butt welded branch connections.

ThredOlets for screwed branch connections.

Socket-End WeldOlets for socket-type welded branch connections.

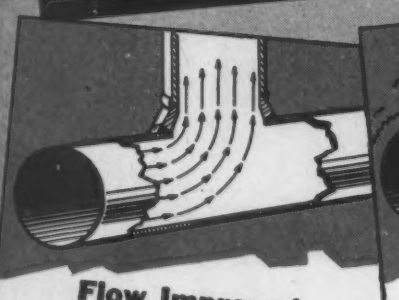


Save Weight

WeldOlets, ThredOlets keep the weight of any piping system to a minimum. Fewer flanged joints mean less possibility of leaks.

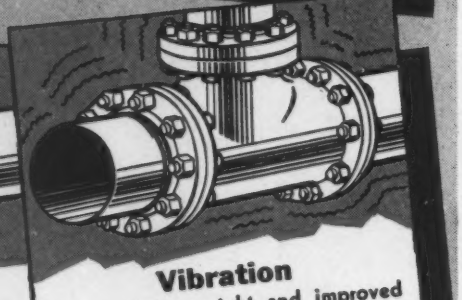
Gaskets, Bolts, Nuts

Maintenance eliminated when WeldOlets, ThredOlets are used—no need to change gaskets, tighten nuts and bolts.



Flow Improved

Funnel-shaped intake aperture of WeldOlets, ThredOlets improve flow conditions, reduces turbulence and friction.



Vibration

Due to light weight and improved flow conditions, vibrational stresses are reduced, possibility of leaks eliminated when WeldOlets, ThredOlets are used.

WeldOlets, ThredOlets and Socket-End WeldOlets are suitable for all commonly used pressures and temperatures in every type of piping system. They are installed either before or after erection of the main line—and always with ease and economy. They are equally well adapted to pre-fabricated or "on-the-job" assemblies. Stocked for all standard pipe sizes up to 12" in size-to-size and reducing sizes—and can be supplied on special order for pipe up to 24". Stock fittings are drop forged steel, but to meet special conditions will be supplied in Monel, Everdur, Toncan Iron, wrought iron, etc.

Bulletin WT31 gives detailed information about all the advantages of WeldOlets, ThredOlets and Socket-End WeldOlets. Write for your copy today.

Forged Fittings Division

Bonney Forge & Tool Works, Allentown, Pa.

ARMY E NAVY

Star Awarded July 10, 1943

WELDOLETS • THREDOLETS

TRADE MARKS REG U S PAT OFF

Welded Outlets for Every Piping System

handle the oil movement to and including delivery to terminal points.

The changes were made to meet criticisms from the industry over the operations of the supply and distribution subcommittees which were charged with having acted in some instances in an arbitrary manner, occasionally without notification to Washington until after action had been taken.

Supply Group Considers Convention Entertainment

Preparations for entertainment for the coming annual meeting of the Natural Gasoline Association of America in Dallas, April 12, 13 and 14, were taken by directors of the Natural Gasoline Supply Men's Association in Tulsa December 29. An entertainment committee was named and a resolution adopted in which the organization took a stand in opposition to individual entertainment in hotel rooms during the meeting.

The following committee was named to arrange for entertainment of the convention the evening of April 13: G. B. Lane, Vinson Supply Company, chairman; F. I. Brenninger, Continental Supply Company; Art Burrell, Cooper Bessemer Corporation; W. R. McLaughlin, Pittsburgh Equitable Meter Company, and H. M. Rosevear, Wyatt Metal & Boiler Works.

Oil Legislation High on Congressional Calendar

The 78th Congress has returned to Washington for its final session, with a number of important oil matters due to come up almost immediately.

The major issue, and one which has an importance far beyond that which it holds for the oil industry, is presented in the Disney bill to increase the ceiling on crude oil prices, already passed by the House and now pending in a Senate committee.

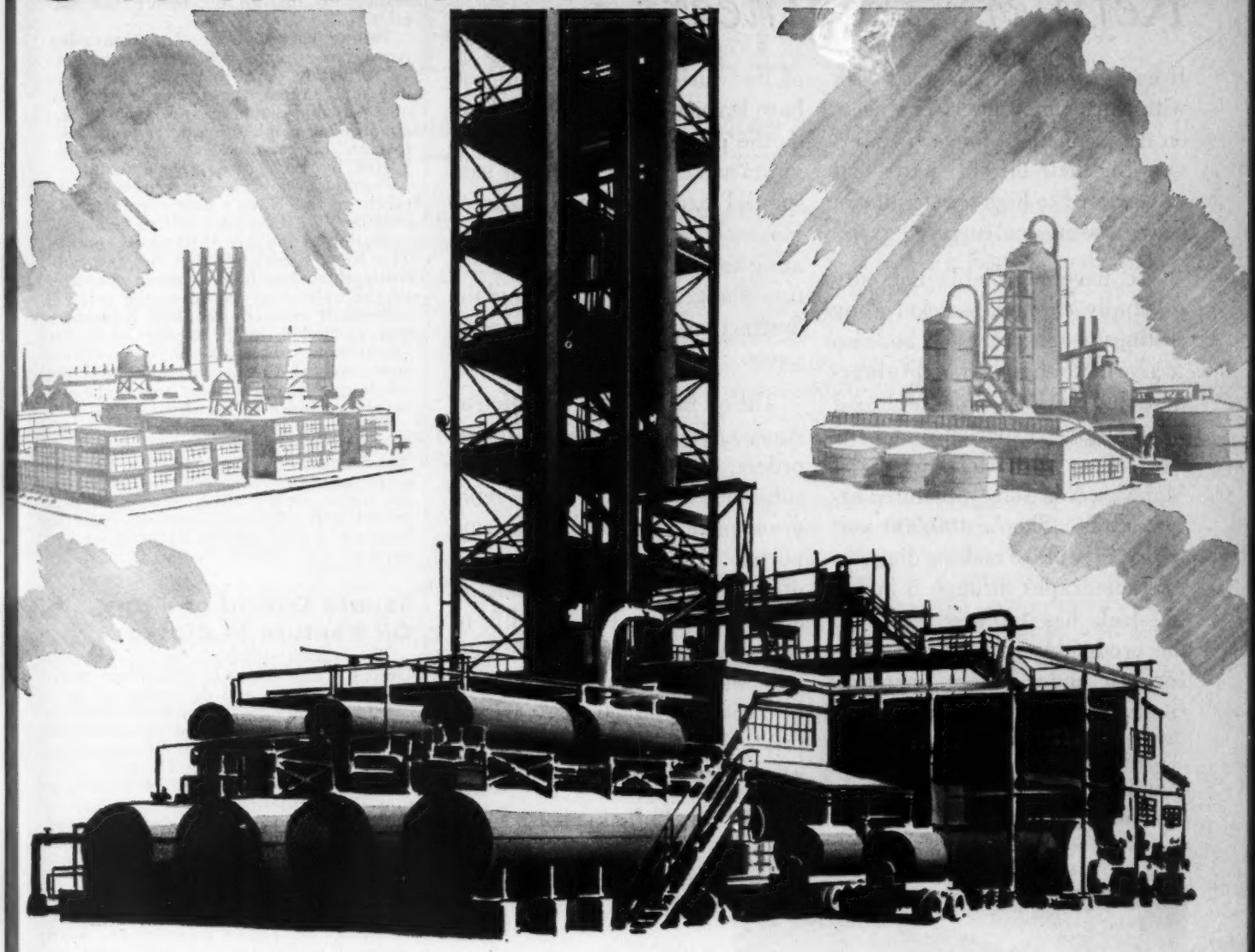
Assailed by the Administration as a drive to nullify its anti-inflation program, the measure will be bitterly opposed when it reaches the Senate floor, possibly in the near future. Combined with other legislation to increase the wages of non-operating railway employees and to ban food subsidies, the bill represents the views of many in Congress that the Administration, while controlling the prices of non-agricultural commodities, has failed in its efforts to stem the rise in the cost of living by its inability or refusal equally to control the wages of labor and the prices of agricultural products.

The Lea committee is expected almost immediately to undertake a new series of hearings, at which representatives of East Coast interests will attack PAW orders and the controls imposed on the distribution of oil in that area.

Petroleum Reserves Corporation also is slated for Congressional consideration, with the hard-boiled Truman committee expected to have something to say on the plan to put the government into the oil business abroad. It is also expected to intervene if any attempt is made to carry out plans reportedly nearing completion in the Interior Department for government producing operations on the public lands.

A major question which may come up during the next few months is that of foreign oil policy generally. This issue has been raised with increasing

OW INDUSTRIAL CHEMICALS



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Wherever you are, you are not very far from a dependable source of supply for Dow Industrial Chemicals. And, regardless of how many plants you operate, the traditional high quality of Dow Chemicals is instantly available.

Requests for information on any of the chemicals listed below will receive prompt attention.

DOW INDUSTRIAL CHEMICALS

Caustic Soda • Aniline Oils • Phenol • Glycols • Hydrochloric Acid • Chlorides • Epsom Salt • and more than 75 others.

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DOW

CHEMICALS INDISPENSABLE TO INDUSTRY AND VICTORY

We Like to Work With *Refinery Engineers . . . . .*

It has been our privilege to work with petroleum refinery engineers on the problem of longer life service for their oil still parts that are exposed to high temperatures, heavy loadings and corrosive gases.

We have been able not only to supply chromium-nickel alloy castings to specifications, but also to give these engineers helpful suggestions, derived from a broad metallurgical experience and the work of our research laboratory at Mahwah, New Jersey, pictured below. Brake Shoe's 400,000 volt X-ray, capable of making diagnostic radiographs through 5 inches of steel, has likewise aided in the production of sound castings for use under severe operating conditions.

Amsco Alloy parts are used in major refinery areas, not only in the United States but in other parts of the world. Refinery engineers have learned that they can depend on the proper grade of this chromium-nickel alloy to retain substantial load carrying strength for maximum periods under still operating temperatures and temperature changes, and to withstand the destructive effect of corrosive gases.

The oil industry's evaluation of Amsco Alloy is reflected in repeat orders, some of which run into substantial tonnages. These refinery applications include tube supports, brick hangers, damper doors, tube sheets, burner nozzles and other parts. The long life of these parts has not only made them economical in themselves, but has also aided production by greater infrequency of shutdowns for replacements.

Ask for Bulletin 108, which contains complete information on Amsco Alloy.

A-419—Brake Shoe's Research Laboratory, Mahwah, N. J.

A-420—6-Unit Creep Testing Machine.

A-228—Amsco Alloy intermediate convection tube sheets.

Amsco
AMERICAN MANGANESE STEEL DIVISION
Chicago Heights, Illinois

AMERICAN Brake Shoe COMPANY

FOUNDRIES AT CHICAGO HEIGHTS, ILL.; NEW CASTLE, DEL.; DENVER, COLO.; OAKLAND, CALIF.; LOS ANGELES, CALIF.; ST. LOUIS, MO.
OFFICES IN PRINCIPAL CITIES

frequency during the past few months before Congressional committees, in PIWC and, in the industry generally, where it is argued that the United States must adopt a definite policy with respect to foreign oil before the war ends.

Failing such action, it is contended, American capital will be reluctant to go to distant parts of the world, where it would have to fight unaided against unreasonable demands and laws of local governments and compete for favor with foreign oil companies strongly supported by their own governments.

Prompt action also is expected to be taken on the Navy's new contract with Standard Oil Company of California for operation of the Elk Hills naval reserve. The Navy is satisfied that the new contract which has been drafted will meet all the objections raised to the original agreement entered into last November and rescinded in September, but the Department of Justice is not entirely approving of the arrangement and the whole question is due for another airing before a House committee.

There are probably two score oil bills pending in House and Senate, but practically all of them will be left unacted upon in committee files. However the major issues which have been presented will offer sufficient material to keep oil a live subject throughout the session.

Senate Critical of Army Oil Venture in Alaska

The Canol project by which the United States Army is doing field work at Fort Norman and delivering oil to a refining plant at Whitehorse, both in Canada, was branded as unwarranted and excessive in cost by the Senate committee headed by Senator Harry F. Truman. The report followed an investigation of several months.

Its findings as to cost were that the project will involve $134,000,000, that $35,000,000 would have been required for providing sufficient petroleum product by other means, consequently the venture represents a waste of $99,000,000.

Further the report was that the work required 65,000 tons of steel, and involved the labor of 4000 soldiers and 12,000 civilians. The refining plant will require 7787 tons of steel and the committee was informed that its cost will be $24,429,270. It cited the estimate from Standard Oil Company of California which was that a plant of similar size and including a catalytic cracking unit could have been built in California for $11,500,000.

The report also was critical of the time element as well as amounts of finished materials.

Drain on Materials

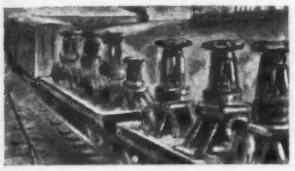
All told, the committee concluded, "instead of helping in 1942 and 1943 when shipping was at its low point, the project was a drain on available transportation facilities, to the detriment of the actual fighting forces in Alaska, which the committee knows, from its investigations in Alaska, suffered from lack of transportation for such essential supplies as lumber. At best the project —designed because of a shipping crisis— would be complete after the shipping crisis had been largely met by our tremendous shipbuilding program.

"Moreover, aside from the time element, the Canol project could not produce enough to make Alaska or even

The 1944 Outlook on STEEL VALVES

A frank statement of the problems facing steel valve users

If you have tried to buy steel valves during the past year you know that they have been among the most critical common components in American war production. Is there any relief in sight? How long will shipments take? Will repair parts be obtainable in 1944? *Here are the facts . . . .*

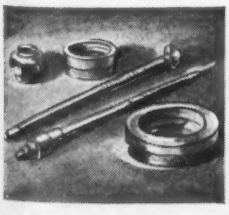


YOU CAN HELP SPEED DELIVERIES. Steel valve production has increased substantially in 1943, but in general has still lagged behind the extremely high demands of the war program. For at least the first part of 1944 this situation is likely to continue. There are, however, several things you can do to speed delivery of the steel valves you will need . . . .

1. Stick to standard valves. "Specials" slow down production, create order handling delays, and increase possibility that your order may not be filled since they usually require non-standard and short-run parts hard to obtain or manufacture.

2. See if a substitute is available. Often the exact type of valve you order may be oversold. In many cases a substitute valve type which will do the job as well will be available on a shorter delivery schedule.

3. Check your order. With steel valves, as with other critical war products, many delivery delays have had nothing to do with production. They have resulted from failure of the purchaser to furnish on the original order complete priority information, product description or service requirements.



WHAT ABOUT REPAIR PARTS? Requirements for maintenance and repair parts are naturally at a very high level as old equipment is stretched for long periods under extraordinarily heavy loads.

When a valve user orders a repair part he usually needs it in a hurry, and so we have given preferred treatment to repair part orders. Within the limitations of government regulations we will continue to emphasize prompt filling of repair part orders. Out of the great volume of part orders we filled in 1943, less than a handful were ever past due.

WHAT'S HAPPENED TO QUALITY? Today's Edward valves are just as good as they always have been. Recognizing that the service into which war valves go is often tougher than peace-time requirements, Edward has never relaxed material and workmanship standards. Actually there have been few changes in the materials used in Edward valves and in no case has inherent serviceability been reduced.

Nor have expanded operations and manpower losses to the armed forces altered the quality of Edward workmanship, for ours is a veteran organization with a large enough nucleus of thoroughly experienced valve builders to retain our rigid policy of every-stage inspection control with absolute power of rejections.

WHAT'S COOKING? Design development did not stop with the war. Edward engineering and laboratory departments have carried on an uninterrupted program of design refinement. Instead of withholding the results of this development program for a post-war splurge, each improved design—as soon as its value has been proved beyond question—was adopted as Edward standard practice in all cases where war production would not be jeopardized by such change.

Additional types of Edward valves will soon be available, probably before the end of the war. You can expect an announcement in the near future.

For as long as the war continues, the Edward plant will devote its facilities to the kind of on-schedule production that has won the Victory Fleet Flag, the Maritime "M" pennant, and an additional Gold Star, without prejudice to the service and planning needs of purely peace-time customers. And when V-day comes, the Edward plant will be ready.

W. F. Crawford

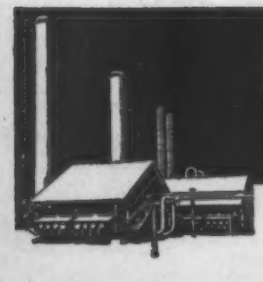
President

The Edward Valve & Mfg. Co., Inc.

Building a complete line of steel valves for all land and marine service temperature and pressure conditions.

EAST CHICAGO E V **INDIANA**

History does not record the discovery of fire, but from the fragmentary story of origins, we learn that civilization began only when primitive man learned to kindle flame. From this costly and precarious luxury, subjugated by ages of weary and uncertain experiment, has come every boon known to mankind. One of the most important benefits of fire is its application for heat in petroleum processing. Pioneering 20 years ago in engineering heaters for hydrocarbons, Alcorn installations in world-important refineries are achieving new peaks in efficiency. Well abreast of the ever changing technique of the industry, Alcorn merits your consultations for the solution of any heating problem.



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Northwestern Canada independent of outside oil products. General Somervell admitted in his testimony that Canol's product would not be a drop in the bucket during a major engagement. It would require months and years of operation without using the products for any other purpose, for Canol to stockpile any sizable quantity of material and this on the assumption that full year-round operation is possible. Irrespective of Canol, the water lanes to Alaska would have to be kept open and the great preponderance of necessary oil products moved to Alaska by water.

"One tanker making a single trip anytime after April 29, 1942, could carry as much 100-octane aviation gasoline to Skagway as would be produced by the entire Canol project by January 1, 1945."

Officials of Oklahoma Utilities Association

Officials and directors of the Oklahoma Utilities Association for 1944 have been elected as follows:

President, E. C. Joullian, Consolidated Gas Utilities Corporation, Oklahoma City; vice presidents, George M. McLean, Oklahoma Gas & Electric Company, Oklahoma City; A. F. Potter, The Gas Service Company, Bartlesville; treasurer, D. S. Kennedy. Oklahoma Gas & Electric Company, Oklahoma City; secretary Kate A. Niblack, Biltmore Hotel, Oklahoma City.

Directors, three year term: A. F. Potter, W. O. Smith, Southwest Natural Gas Company, Ada; directors, one year term: J. P. Arnold, Public Service Company of Oklahoma, Tulsa; George A. Davis, Oklahoma Gas & Electric Company, Oklahoma City; J. C. Happenny, Oklahoma Power & Water Company, Sand Springs; E. C. Joullian; R. K. Lane, Public Service Company of Oklahoma, Tulsa; directors, hold over: Glenn C. Kiley, Oklahoma Gas & Electric Company, Oklahoma City; Frank B. Long, Oklahoma Natural Gas Company, Tulsa; S. I. McElhoes, Southwestern Light & Power Company, Chickasha; W. L. Woodward, Zenith Gas Systems, Inc., Alva.

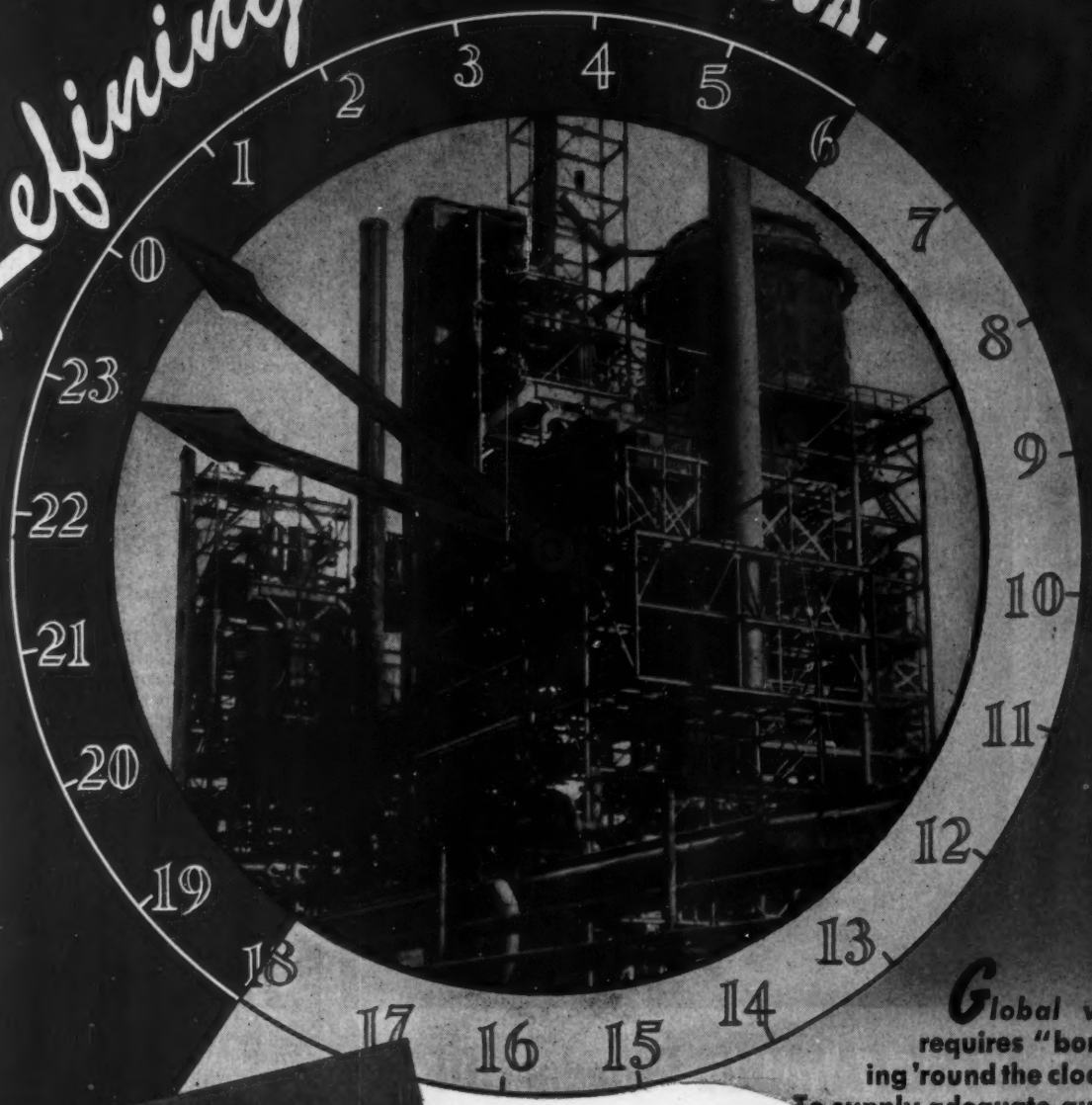
Division of Rubber Chemistry to Meet

The Spring meeting of the Division of Rubber Chemistry of the American Chemical Society will be held in New York, April 26, 27, and 28, separate from the 107th meeting of the parent society.

The American Chemical Society meeting is scheduled to be held in Cleveland, Ohio, from April 3 to 7, but after a careful study of housing facilities in Cleveland, the executive committee of the division of Rubber Chemistry decided in view of the continuing problems of transportation and housing accommodations to hold the meeting of this division again in New York.

The Hotel Commodore has been again selected as the headquarters for the Rubber Division meeting, and the main ballroom, ballroom foyer, and Parlor A have been reserved for the entire meeting period. An opportunity for preregistration will be provided. Hotel room reservations for attending members and guests must be made directly with the hotel by everyone planning to attend this meeting. Guaranteed hotel reservation cards have been mailed to all members of the division and registration cards will be mailed in the near

Refining 'round the clock.



Global war requires "bombing 'round the clock." To supply adequate quantities of fuel for our bombers, American refineries producing high-octane aviation gasoline must continue "refining 'round the clock."

Fluid catalytic cracking plants designed and constructed by Kellogg are contributing their full share to this program by producing at capacity on 24-hour per day schedules.

As Allied bombings are stepped up in intensity, additional Kellogg-built plants about to go on the line will augment our output of vital aviation gasoline and insure no let-up in our softening up program.

KELLOGG

THE M. W. KELLOGG COMPANY
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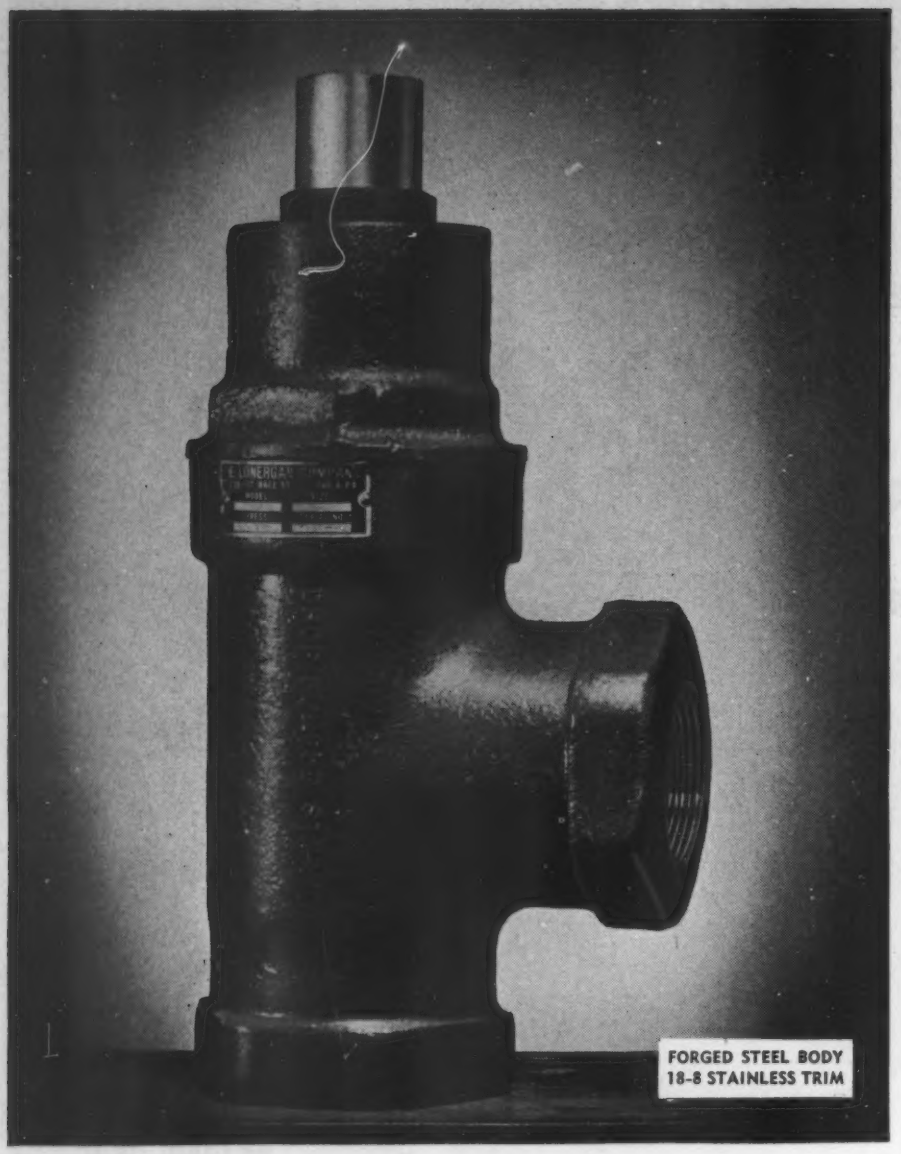
CATALYTIC PROCESSES for Cracking, Hydroforming, Reforming, Dehydrogenation, Alkylation, Desulphurization
GASOLINE PRODUCTS COMPANY, INC....Pyrolytic Cracking • THE POLYMERIZATION PROCESS CORPORATION...Thermal and Catalytic Polymerization
JUIK Processes . . . for Lubricating Oil Refining with Propane and Phenol • Deasphalting • Dewaxing • Solvent Extraction and Acid Treating Plants



THIS IS THE FAMOUS "Model HDF"

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future. The banquet is scheduled for the evening of April 27. Under present day conditions, it cannot be overemphasized that reservations should be made early.

It is hoped that all members of the division as well as others interested in the problems and progress of any phase of the science and technology of natural and synthetic rubbers and related materials, who can arrange to do so, will attend this meeting. In the course of the past two years, rubber has become and still is one of this country's major problems. Ways and means of solving some of these problems as can be discussed in wartime will be presented at this spring meeting. Consumption of rubber in the United States in 1943 was about 424,000 long tons, while consumption in 1944 will be about 757,000 long tons, according to estimate by the Office of the Rubber Director, of which most of the latter tonnage will be synthetic rubber. Putting this increased tonnage of synthetic rubber to the best use will be the subject of many of the papers presented at this meeting.

Latonia Becomes Part of Sohio Petroleum Company

The Latonia Refining Corporation, Latonia, Kentucky, was one of the subsidiaries of The Standard Oil Company (Ohio) to become a part of Sohio Petroleum Company, which was formed to take over several subsidiary concerns. Others included in the merger were Sohio Producing Company and Sohio Corporation.

Officials of Sohio Petroleum Company are W. T. Holliday, president; S. A. Swensrud, G. W. Hanneken and W. J. Sample, vice presidents and also vice presidents of the parent company. Vice presidents of the subsidiary company are J. F. Wilson, John R. Smoots and Earl D. Wallace.

New Plant Engineering 75 Percent Complete

Engineering is more than 75 percent completed on the 22 additional plants, which will complete the 100-octane aviation gasoline facilities for the nation, according to an announcement by Harold L. Ickes, Petroleum Administrator.

"By this time next year we expect these plants to be completed and increasing substantially the stream of aviation fuel, flowing to the fighting fronts," he explained. "How much of this gasoline is being used or will be needed can not be revealed. But it is expected that with the added production from these plants the volume of fuel will be raised to levels adequate to meet the war demands."

Shell's Wood River Plant Gets a Star

A star has been added to the Army and Navy "E" banner flying over Shell Oil Company's refinery at Wood River, Illinois.

For the second time within a year the production award for achievement in the production of war products has been conferred upon the workers at this refinery, which was the first to receive such an award from the Army and Navy.

The Wood River refinery is producing high-octane gasolines, toluene for TNT, turbine oil and aviation lubricants.

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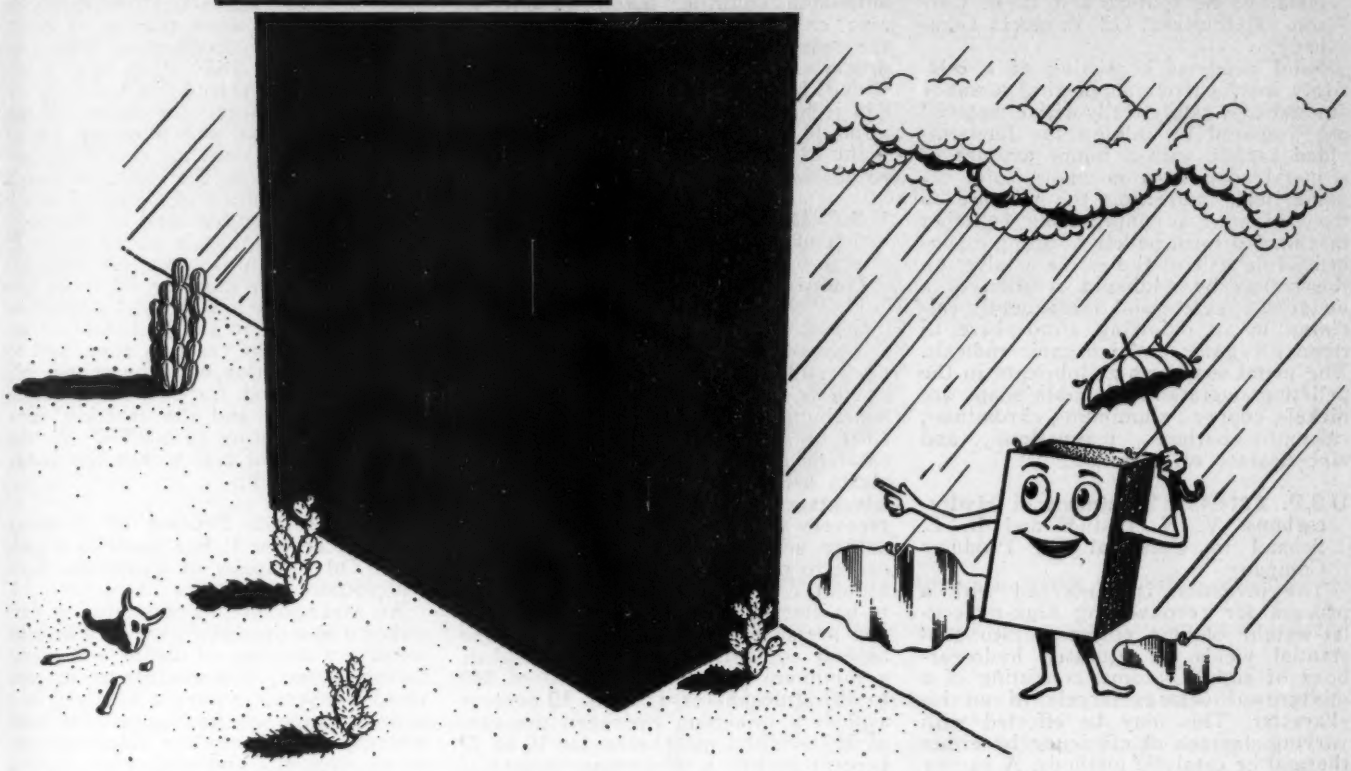

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DIGEST OF UNITED STATES PATENTS

On Catalytic Hydrogenation of Hydrocarbons

Compiled by Heinz Heinemann

U.S.P. 2,211,208. Manufacture of Catalysts. V. N. Ipatieff and B. B. Corson to Universal Oil Products Company.

Solid catalysts consisting of a relatively inert carrier supporting a minor amount of a catalytically-active material are prepared by mixing the finely-divided carrier with a minor amount of a metal soap of a normally solid organic acid, subjecting the mixture to the action of a reciprocating pelleting machine to form pellets, forming a superficial deposit of the active catalyst on the pellets by adding a solution of a metal salt thereto and subsequently calcining in an oxidizing atmosphere to remove organic and inorganic radicals. The metal soap acts as lubricant in the pelleting operations. Suitable soaps are nickel-, copper-, aluminum-, chromium-, calcium-, barium-, magnesium-, and zinc-stearate or palmitate.

U.S.P. 2,214,463. Treatment of Hydracarbons. V. N. Ipatieff and R. E. Schaad to Universal Oil Products Company.

The invention is concerned with a process for reconverting high-molecular-weight olefinic polymers into substantial yields of saturated hydrocarbons of eight C-atoms, consisting of a mixture of octanes largely of an iso character. This may be effected with varying degrees of efficiency by either thermal or catalytic methods. A variety of catalysts may be employed such as nickel, nickel oxide, nickel thio molybdate, corresponding compounds of cobalt, oxides and sulfides of the metals in the left-hand column of group 6 of the periodic table, including chromium, molybdenum, tungsten and various other catalysts. Such catalysts may be employed as such in finely divided condition or distributed upon relatively inert supports such as kieselguhr, fuller's earth, active coal, etc. A temperature of 250 to 300° C. and an initial pressure of approximately 100 atmospheres are used for the reaction.

U.S.P. 2,215,876. Hydrogenation of Liquid Olefin Polymers. P. Herold, W. Kroenig, H. Kaufmann and E. Donath to Standard-I. G. Company.

Liquid olefin polymers within the boiling range of gasoline are hydrogenated in contact with catalysts substantially free of halides and of materials having appreciable cracking action under the conditions of treatment and which contain at least one of the sulfides of molybdenum and tungsten together with at least one of the sulfides of nickel and cobalt to effect hydrogenation without cracking.

U.S.P. 2,216,372. Synthetic Hydrocarbon Oils and Method of Making Same. A. L. Lyman and E. W. Gardiner to Standard Oil Company of California. C.A. 35, 1217.

An arrangement of apparatus is described and a process which involves treating mixed gases from the pyrogenetic cracking of petroleum oils, as by polymerization in the presence of aluminum chloride, boron fluoride or zinc chloride and hyrogenation, with the resultant obtaining of a stable hydrocarbon oil, suitable for various uses, which is liquid at room temperature and is composed of branch-chained paraffins in major proportion, has a cloud point of O°F or below and a general empirical formula of C_nH_{2n} to C_nH_{2n+2}.

U.S.P. 2,227,671. Process of the Production of Valuable Hydrocarbon Products by Treatment of Carbonaceous Material with Hydrogenating Gases. M. Pier, W. Simon and E. Donath to Standard-I. G. Company.

Valuable hydrocarbon products, in part motor fuels, are obtained from liquid or fusible carbonaceous materials containing asphalt at high temperatures (300 to 500°) and high pressures by catalytic hydrogenation. Stationary catalysts are employed with the obvious advantage of longer catalyst life, easier recovery and regeneration. Tungsten disulfide acts as a suitable catalyst. In order to prevent catalyst poisoning, the asphalt content of the charge oil has to be determined and the partial hydrogen pressure adjusted according to the asphalt content. For 2 percent asphalt a minimum hydrogen pressure of 300 to 350 atmospheres, for 2 to 10 percent asphalt a minimum hydrogen pressure of 350 to 420 atmospheres, for 10 to 20 percent asphalt a minimum pressure of 420 to 500 atmospheres, and for 20 to 30 percent asphalt a minimum pressure of 500 to 600 atmospheres are required.

U.S.P. 2,227,672. Thermal Treatment of Carbonaceous Materials with Suitable Catalysts. M. Pier, W. Simon, P. Jacob and R. Becker to Standard-I-G. Company.

Improved hydrocarbon oils are obtained by destructive hydrogenation in the presence of catalysts. The hydrocarbons are subjected to a thermal treatment to produce products having a number of C-atoms in the molecule which is not greater than that of the initial material. The reaction temperature range is from 180 to 700° C. in the presence of a mixed catalyst comprising 97 to 60 parts of a component A consisting of at least one metal of a weakly hydrogenating action, selected from the class composed of iron and zinc in the form of a preformed compound of sulphur and 3 to 40 parts by weight of a component B consisting of at least one substance of a strongly hydrogenating action selected from the group consisting of the metals molybdenum, tin, tungsten, rhenium, uranium, chromium, vanadium, nickel, cobalt and compounds thereof.

U.S.P. 2,232,909. Hydrogenation Process. E. J. Gohr to Standard-I-G. Company.

The invention relates to an improvement in the treatment of vaporized carbonaceous material with hydrogenating gases in the presence of catalysts containing sulphur and is directed particularly to methods for regulating the activity of such catalysts. These catalysts are more active when sulphur is introduced into the hydrogenating zone during the reaction. Difficulties have, however, been encountered due to vaporization of the charge, deposition of the elemental sulphur and plugging up of preheater and reaction-chamber entrance zones. It is, therefore, proposed to prepare a solution of about 0.5 to 2.0 percent (based on the total oil charged) of elemental sulphur in about 10 to 25 percent (based on the total oil charged) of an oil heavier than the oil to be hydrogenated, which will not be substantially vaporized in the preheater of inlet portion of the reaction zone, and to admix this solution with the charge oil. If the charge-oil fraction boils within 200 to 500° F. and the reaction zone is at a temperature of 600-950° F., the heavy oil should boil within the range of 500 to 850° F.

U.S.P. 2,241,393. Process of Treating Hydrocarbons. P. S. Danner to Standard Oil Company of California. C.A. 35, 5686.

An arrangement of apparatus is described and a process which may involve forming a mixture of olefins and naphthenes, passing the mixture at an elevated temperature over a catalyst in a hydrogenation - dehydrogenation zone whereby naphthenes are dehydrogenated to aromatics and olefins are hydrogenated to paraffins, quenching the vapors leaving this zone by direct contact with a high-boiling organic selective solvent for cyclic hydrocarbons in liquid phase to simultaneously stop undesired side reactions and effect a separation of paraffinic from cyclic hydrocarbons, separating the solvent containing dissolved cyclic hydrocarbons from undissolved paraffinic vapors and recovering naphthenes and aromatics from the solvent.

U.S.P. 2,242,627. Hydrogenation Catalyst and Process. T. G. Strickland to Phillips Petroleum Company.

An active and rugged catalyst for the non-destructive hydogenation of hydrocarbons and its preparation is described and hydrogenation reactions therewith are discussed. A catalyst suitable for the hydrogenation of commercial mixtures of olefinic polymers in the gasoline boiling range can be prepared by forming an intimately associated mixture of nickel oxide, copper oxide and aluminum oxide upon an inert support and treating this material with hydrogen. An aqueous solution of nickel nitrate, copper nitrate and aluminum nitrate is mixed with a granular inert support and the water is evaporated. The nitrates are decomposed in a stream of air, raising the temperature gradually to 650 to 750° F. The oxides then are reduced with hydrogen at a slightly elevated temperature. The catalytic composition should contain 5 to 25 percent by weight of the metals as aluminum and 10 to 50 percent as copper. Oxygen containing impurities of

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hydrocarbons can be hydrogenated to water with this catalyst.

U.S.P. 2,249,367. Production of Silver Catalysts. G. H. Visser to Shell Development Company.

Silver catalysts prepared according to this invention are very effective for the hydrogenation of unsaturated organic compounds. In their presence ethylene can be substantially completely hydrogenated to ethane at temperatures as low as 170° C. The catalysts are produced by reducing a silver compound in an aqueous medium by means of nascent hydrogen generation in said medium by dissolving therein a metal which is above hydrogen in the electromotive series of the elements and is soluble in the aqueous medium, separating the resulting silver metal from the reaction mixture and drying the silver metal substantially out of contact with air whereby finely divided substantially pure silver metal is obtained.

Reissue 21,932. Process for Converting Hydrocarbons. F. E. Frey and W. F. Huppke to Phillips Petroleum Company.

Catalysts usable for both hydrogenation and dehydrogenation reactions are described. Chromium oxide in the form of a hard dark-colored vitreous gel has been recommended. While highly active in the useful temperature range, it passes at 550 to 600° C. into the common inert form of chromium oxide. The activity is lost and cannot be restored by oxygen treatment. The addition of certain difficulty-reducible oxides having little activity in themselves will delay or prevent the transformation of chromium oxide into the inactive form at temperatures within the working range. Such compounds are the infusible oxides, alumina, zirconia, thorium oxide, boric oxide, magnesium oxide, silicon dioxide and titanium dioxide, incorporated in the chromium oxide in such a way that the gel characteristics are conserved. This may be accomplished by precipitating together from aqueous solution the gelatinous hydrous oxides of chromium and one or more of the elements named. To effect hydrogenation of olefins or diolefins, temperatures of 200 to 500° C. are used, preferably the lower temperature and a high partial pressure of hydrogen and pressures above atmospheric are desirable but not necessary. Catalytic action can be restored by treating with an oxygen containing gas at elevated temperatures.

U.S.P. 2,270,165. Catalyst. H. P. A. Groll and J. Burgin to Shell Development Company. C.A. 36,3330.

At least one metal of the first transition series of the periodic table having an atomic number less than 26 is used together with an "activated alumina" such as that of commerce in larger proportion, the metal being incorporated in the surface of the "activated alumina."

U.S.P. 2,270,303. Hydrogenation of Hydrocarbons. V. N. Ipatieff to Universal Oil Products Company.

A catalyst and hydrogenation conditions for the hydrogenation of octenes to octanes and particularly of those octenes produced as dimers of butanes are described. A general method of preparation of the catalyst involves the following steps: kieselguhr is suspended in a relatively dilute aqueous solu-

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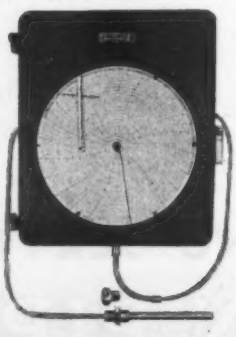

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tion of nickel sulphate and a saturated hot solution of Na_2CO_3 is added gradually under agitation, the proportions of kieselguhr, nickel sulphate and sodium carbonate being chosen so that after washing and drying the precipitate, pelleting in admixture with graphite and reducing with hydrogen a composition is obtained which corresponds to 62 percent total nickel, 4 percent oxygen in nickel oxide, 6 percent graphite, 28 percent kieselguhr. Hydrogenation with this catalyst takes place best at 170 to 215° C. and at pressures from 0 to 200 pounds with a molal excess of less than 60 percent hydrogen and a liquid space velocity of 4 per hour.

U.S.P. 2,271,017. Method of Producing Hydrogenated Hydrocarbon Products. R. Lepestre to Applied Chemicals, Inc.

A process for increasing the hydrogen content of hydrocarbon products which consists in preparing an aqueous colloidal mixture of a hydrocarbon base material, simultaneously injecting said mixture and a hydrogen carrier at a pressure range between 12,000 and 14,000 pounds into a chamber within which a temperature of approximately 1000° F. is maintained and causing said base material and hydrogen carrier to be brought into direct impingement at a common focal point in said heated chamber, circulating the mixture formed in said chamber at a predetermined speed by and in contact with a catalyst and subsequently by cooling and condensing the gaseous products resulting from the catalytic reaction.

U.S.P. 2,275,181. Process for Hydrogenating Hydrocarbons. V. N. Ipatieff and B. B. Corson to Universail Oil Products Company.

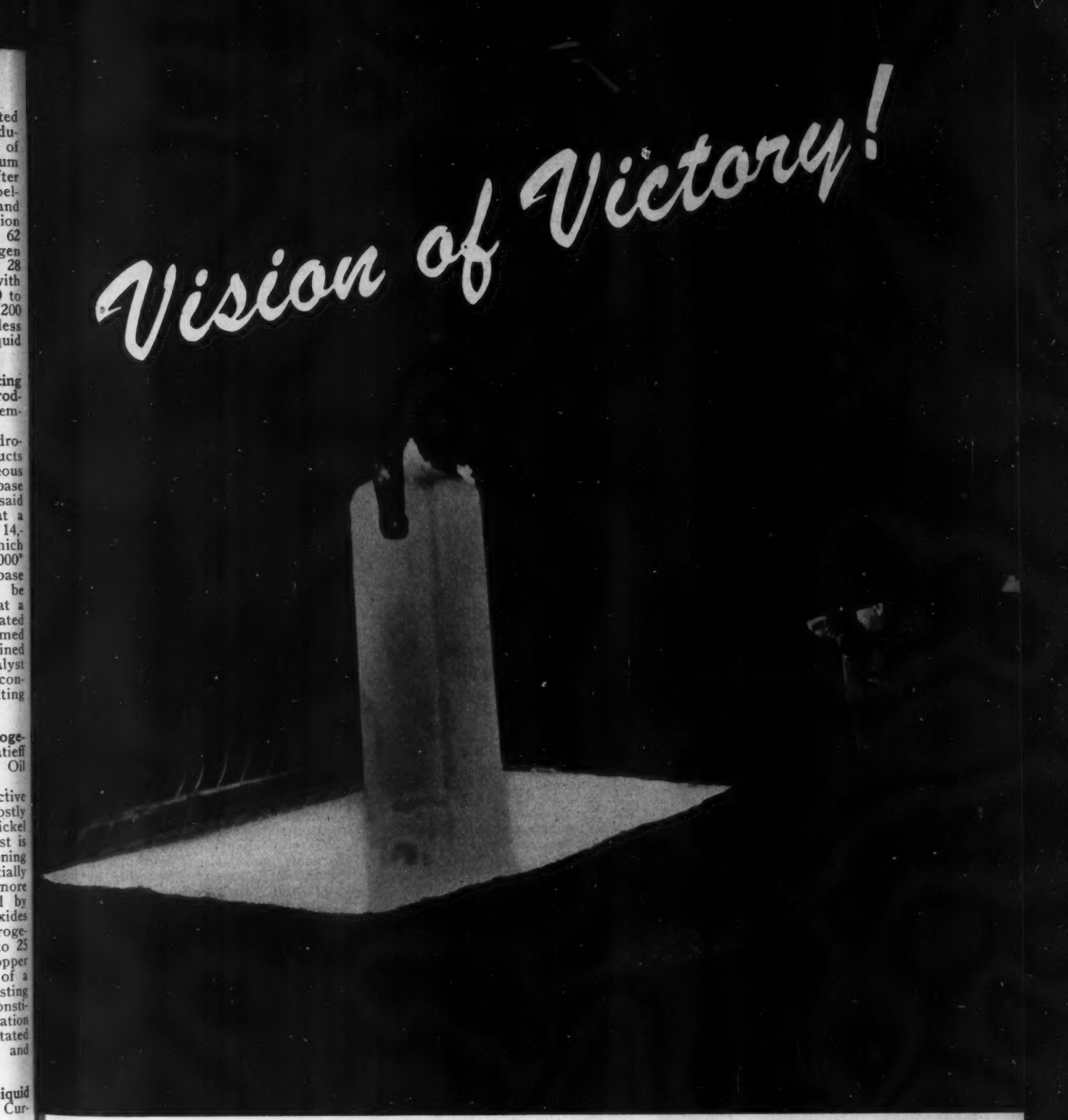
Catalysts for direct non-destructive hydrogenation have previously mostly been prepared by reduction of nickel oxide. The use of this type catalyst is limited by its sensitivity to poisoning Although pure copper is substantially without hydrogenation activity a more rugged catalyst may be prepared by adding thereto certain metal oxides which alone again have little hydrogenation activity. A mixture of 95 to 25 percent by weight of reduced copper and 5 to 75 percent by weight of a metal oxide from the group consisting of zinc oxide and iron oxide constitutes such a catalyst. For preparation the components may be coprecipitated and reduced or singly prepared and admixed.

U.S.P. 2,280,258. Manufacture of Liquid Hydrocarbons. M. Pier to W. E. Currie.

Hydrocarbon fractions are hydrogenated at 350 to 510° C. and 20 to 1000 at (preferably 100 to 1000 atmospheres) with alkylation or polymerization catalysts consisting of oxides, sulfides, halides and/phosphates of the heavy metals with or without carriers in such a way that olefins are introduced into the reaction in an amount of at least 10 percent by weight of the oil treated at a moment when the oil has already undergrone considerable splitting.

U.S.P. 2,282,451. Desulphurizing and Cracking Process. B. T. Brooks to Standard Alcohol Company.

The purpose of the invention is to remove sulphur from cracking stocks before entering the main cracking reaction. For this purpose the cracking



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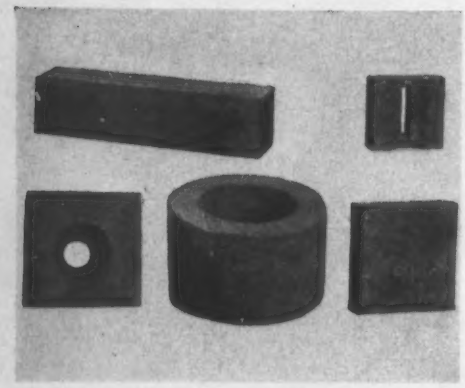

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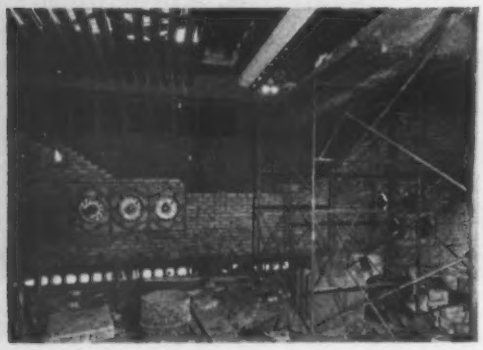

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feed stock is desulphurized in the presence of hydrogen at about 5 to 50 atmospheres and 250 to 350° C. using metal sulphide hydrogenation catalysts, in particular sulphides of molybdenum, tungsten, chromium and uranium. If the feed stock is fairly low in sulphur (0.1 to 1 percent), it is desirable to carry out the prelminary desulphurization reaction under mild cracking conditions. In this case it is also desirable to recycle some H_2S to maintain catalyst activity on account of the equilibrium relationship between the catalyst and H_2S.

U.S.P. 2,295,808. Treatment of Hydrocarbons. R. E. Schaad to Universal Oil Products Company.

Anti-knock motor fuel is produced from substantially saturated hydrocarbons by subjecting the oil to destructive hydrogenation and thus producing a substantial quantity of i-butane. An i-C_4 fraction and a fraction higher boiling than hexane are separated, the latter is dehydrogenated to olefins and the mixture of olefins and i-butane is alkylated.

U.S.P. 2,303,075. Catalytic Hydrogenation Process. F. E. Frey to Phillips Petroleum Company.

An improved process for the catalytic, non-destructive hydrogenation of unsaturated organic material is claimed which comprises passing a charge stock comprising substantially unsaturated organic material to which has been added at least an equal volume of saturated organic material and a suitable amount of hydrogen to a first hydrogenation chamber containing a hydrogenation catalyst while at a super atmospheric pressure and at a non-destructive hydrogenation temperature, adding additional portions of said unsaturated materials at a plurality of points to the mixture in said hydrogenation chamber and maintaining a reaction time such that only about 90 mol percent of the organic material in the effluent of said chamber is saturated, passing at least a portion of the effluent of said first hydrogenation chamber through a second hydrogenation chamber containing a hydrogenation catalyst and maintained under substantially adiabatic condtions within a temperature range suitable for non-destructive hydrogenation, and separating from the effluent of said second hydrogenation chamber a fraction comprised essentially of saturated material produced.

U.S.P. 2,303,118. Process for The Catalytic Hydrogenation of Liquid Hydrocarbons. F. E. Frey to Phillips Petroleum Company.

The invention relates to catalytic non-destructive hydrogenation of normally liquid hydrocarbons and particularly to olefin hydrocarbons boiling in the range of motor fuel and not above about 375° F. such as the C_7-C_{11} olefins. The exothermic nature of such reaction makes temperature control of the catalyst bed difficult. According to the invention, hydrocarbons are introduced as liquid and vapor in the presence of hydrogen to a catalyst bed and by maintaining pressure, concentration, and molecular weight within certain limits, hydrogenation is caused to take place with absorption of heat by progressing vaporization of liquid at the catalyst surface and at the temperature of the reaction whereby both mass and local temperature rises are limited. Tempera-

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ture range is 250 to 550° F. and pressure range about 300 to 1000 pounds. The unsaturated hydrocarbons are admixed with saturated hydrocarbon material of corresponding boiling range. At least part of the reacting hydrocarbon material should still be in liquid phase immediately before leaving the reaction zone.

U.S.P. 2,310,278. Hydrogenating with Catalyst. G. C. Connolly to Standard Catalytic Company.

A process for the destructive hydrogenation of hydrocarbon oils is claimed which comprises passing a mixture of said oil and hydrogen containing gas through a hydrogenation zone maintained under destructive hydrogenation conditions of temperature, pressure and relative proportion of hydrogen and oil, and contacting said hydrogen and oil while within said zone with a catalyst comprising a carrier composed of silica and alumina formed by impregnating silica hydrogel with a compound of aluminum convertible to the oxide and thereafter converting said aluminum compound to the oxide, said carrier so formed being impregnated with an active hydrogenation catalyst and maintaining said oil and hydrogen within said zone for a period sufficient to destructively hydrogenate said oil.

U.S.P. 2,313,241. Process for the Cracking of Oils. A. C. Jessup to Ch. Weizmann.

A process of cracking an oil material which comprises subjecting such oil material to the action of hydrogen gas introduced as such, under a pressure of several atmospheres, while in the presence of freshly reduced iron while in a copper apparatus at a temperature of about 380° C., until the sulphur content of the oil is substantially lowered, and until a substantial amount of low-boiling hydrocarbons have been produced.

A.S.T.M. Specifications

The sixteenth edition of this compilation of A.S.T.M. Standards on Petroleum Products and Lubricants gives in their latst form some 80 specifications, tests and definitions that have been standardized through the work of Committee D-2 on Petroleum Products and Lubricants. The work of this committee has been given national and international recognition through approval of many of its standards by the American Petroleum Institute, American Standards Association, and acceptance by the British Institute of Petroleum Technologists.

New items in the book for the first time include a test for oil content of paraffin wax (D 721), the emergency method of test for color of U. S. Army motor fuel (ES 32), and also new are two proposed tests published for information and comment covering saponification number of petroleum products by electrometric titration and a test for oxidation characteristics of steam turbine oils, the latter based on extensive research work.

Extensive changes were made during 1943 in many of the standards including the following: Knock characteristics of aviation and motor fuels, viscosity temperature charts, and others were affected by more or less minor modifications.

Copies of this publication can be obtained in heavy paper cover from A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia 2, Pa., at $2.25 per copy.

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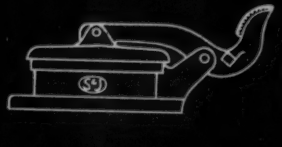

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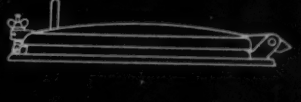

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The abstracts here presented are selected from the current literature of science and technology to afford reference to fundamental information not easily available to all readers. Abstracts of articles appearing in readily obtainable trade journals are not included.

Photostat copies of original articles will be supplied at cost by the Leslie Laboratories. Complete or limited bibliographies covering special topics by title, by abstracts, or in complete manuscript, will also be prepared and furnished at reasonable cost by the Laboratories.

Fundamental Physical And Chemical Data

Physical Constants of the Principal Hydrocarbons, Fourth Edition, Compiled by M. P. Doss, The Texas Co., 135 E. 42nd St., New York 17, N. Y., 215 pp. Price $3.75.

Constants of nearly 2000 hydrocarbons are included. New or corrected data have been added to more than 100 pages in this edition, particularly with respect to the hydrocarbons related to war products such as aviation gasoline, synthetic rubber, toluene, synthetic resins, and the like.

The Properties of Fluids, S. C. Bradford, *Phil. Mag.* **34** (1943) pp. 433-71.

The kinetic theory of Maxwell is extended to liquids so as to include the properties of associated liquids. A general equation of state for a fluid is derived theoretically. From the equation so obtained, expressions are derived for the latent heat, vapor pressure and viscosity of an associated liquid. In the derivation no arbitrary units are introduced. The same procedure is applied to the derivation of the thermal conductivity and the viscosity of a gas. The formulas, when applied to specific cases, agree with observed values to two significant figures. Edser's law of molecular attraction determines liquid properties in a manner analogous to that of the law of gravitation. Constants at different temperatures are calculated for n-hexane, acetone, ether, benzene, chloroform and carbon tetrachloride. From the theoretical considerations developed the most probable speeds of the molecules can be calculated. They are greater than that of the molecules of an ideal gas at the same temperature. The mean free paths are calculated at two temperatures in the range 273-354° absolute for n-hexane, ether, benzene, chloroform and carbon tetrachloride. The formulas given can be adapted to any law of force operating between the molecules. When Edser's inverse-8th power law is used theory and observation agree to within two significant figures. Calculations are also made for the potential energy of a liquid and for the work done when a molecule passes from one fluid phase to another. A formula is derived covering the mixture of fluids of all kinds such as gases in liquids, the miscibility and solubility of liquids in one another, osmotic-pressure effects, surface adsorption, and vapor pressure and boiling point of solutions. The calculated and observed values of the latent heats are compared at two temperatures for, hydrogen, oxygen, nitrogen, acetone, ether, n-hexane, benzene, chloroform and carbon tetrachloride. Values of the vapor pressures are calculated and also values for molecular volumes. The thermal conductivities and viscosities are also calculated including data for acetone, ether, n-hexane, benzene, chloroform and carbon tetrachloride. The methods used in the calculation can also be extended to include solids.

Three Types of Energy of Viscosity, A. E. Dunstan and A. H. Nissan, *Phil. Mag.* **34** (1943) pp. 479-86.

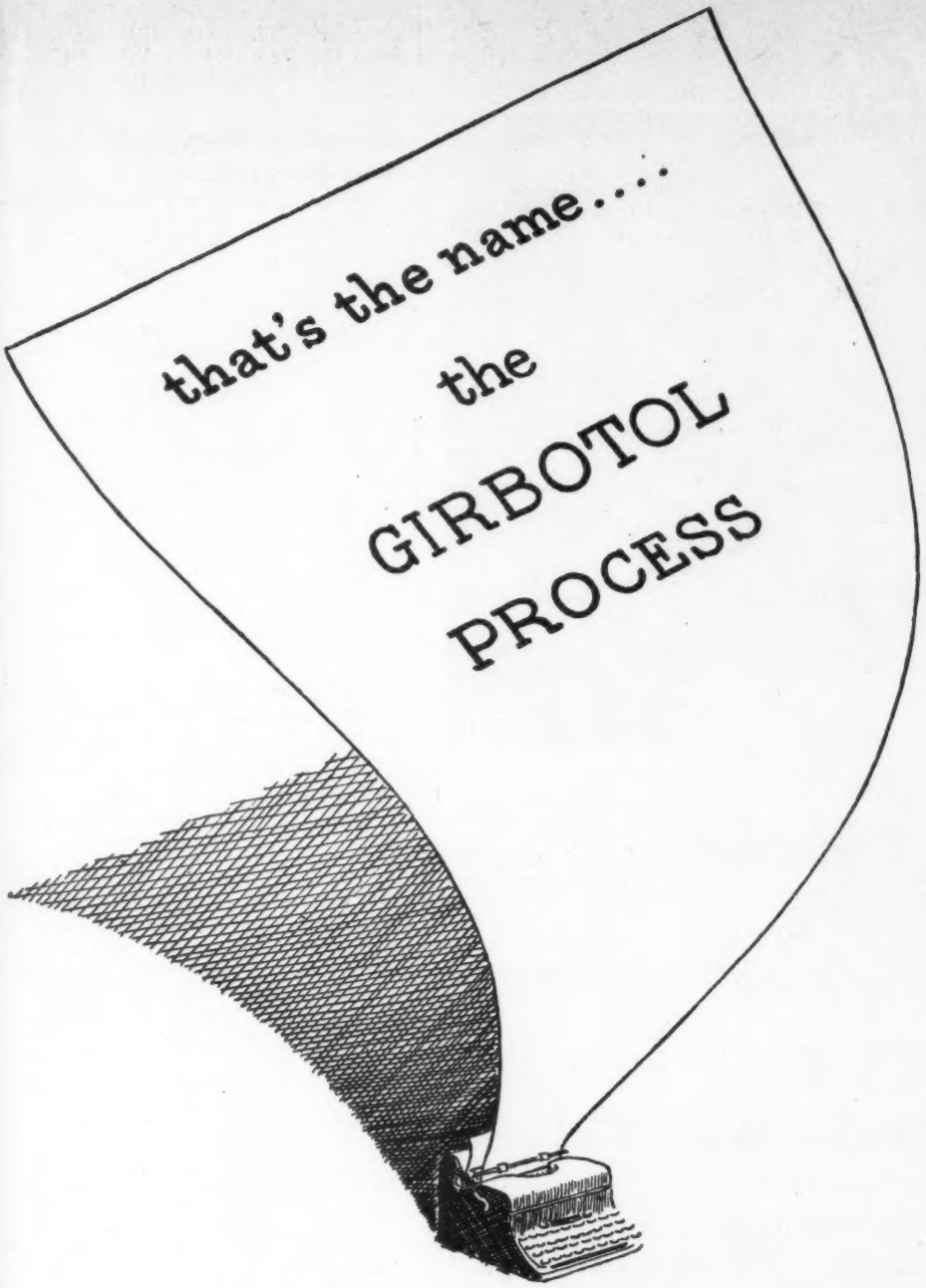
Three energy terms are needed to determine the viscosities of simple liquids. The first is invariant, or only slightly affected by temperature. The other two terms increase rapidly numerically with temperature, but the rates of increase differ and have opposite signs. At the critical point they equate and cancel each other. The authors offer an explanation of the 3 energies in terms of attractive and repulsive forces. Similar considerations probably obtain for the latent heat of evaporation because the energy of viscosity is a constant fraction of the heat of vaporization, and both disappear at the critical temperature. There is an inherent increase in the viscosity of a liquid as temperature increases but this is masked by a larger decrease. The opposite is true of gases. The mechanism of viscosity is probably the same for both gases and liquids. The three energy terms are calculated at different temperatures for the substance n-octane.

Heat of Solution of Ethane and Propane, R. A. Budenholzer, B. H. Sage, and W. N. Lacey, *Ind. & Eng. Chem.* **35** (1943) pp. 1214-20.

Experimental information concerning the heat of solution of the lighter hydrocarbons is scarce, and for this reason a study of the change in enthalpy resulting from the solution of ethane and propane in a relatively nonvolatile, water-white oil was undertaken. The experimental program included both calorimetric and volumetric measurements in the temperature range 100° to 220° F. and at pressures up to 500 pounds per square inch. The experimental method used, and the procedure, materials and apparatus, are described in some detail. The experimental results for enthalpy change for the solution of propane and for the solution of ethane are presented in some detail in tabular form. The results indicate a gradual decrease in the enthalpy change for solution of propane as the weight fraction of propane in the liquid phase increases. The change in enthalpy during solution is equal to the latent heat of vaporization when the composition corresponds to pure propane. A series of measurements of the latent heat of vaporization of propane at 100° F. was made and the values are recorded in tabular form. The results are in good agreement with previously published data. Comparison is made between the results obtained from calorimetric determination and those calculated from the volumetric behavior of the system. Values obtained by the two methods are within the maximum experimental uncertainty. A bibliography of 13 references is included.

Infrared Spectroscopy, R. Bowling Barnes, U. Liddel, and V. Z. Williams, *Ind. & Eng. Chem., Anal. Ed.* **15** (1943) pp. 659-709.

Infrared spectroscopy has proved a powerful tool in solving problems of organic chemistry and finds a widening field in industry. The theory of infrared absorption and its relation to molecular structure are discussed to provide the essential background for detailed descriptions of techniques useful in analysis. A library of 363 representative spectrographs of organic compounds taken in the rock salt region of the infrared spectrum are presented for comparison with those obtained from unknown compounds under investigation. Because of the high value of this comprehensive article as a work of reference a special arrangement has been made to have it published in permanent book form instead of the usual reprint. In addition to the material presented in the article, the book will contain a bibliography of the literature of infrared



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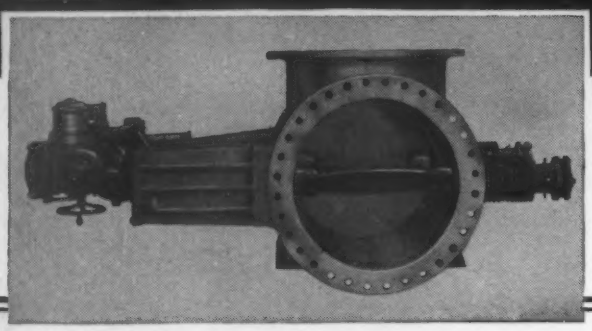

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spectroscopy consisting of some 2000 references. The book will be obtainable from the Reinhold Publishing Corporation, 330 West 42nd Street, New York 18, New York.

Chemical Compositions And Reactions

Synthesis of 1, 4-Epoxycyclohexane, R. C. Olberg, H. Pines, V. N. Ipatieff, *Jour. Amer. Chem Soc.* **65** (1943) p. 2260.

It was expected that refluxing 1,4-cyclohexanediol in the presence of activated alumina would yield cyclohexadienes and cyclohexanol. It was found, however, that 1,4-epoxycyclohexane is formed predominantly. 1,4-Epoxycyclohexane boils at 120.1°C (760 mm.) d^{20}_4 0.9707, $n^{20}D$ 1.4477, and formula $C_6H_{10}O_2$. It is soluble in the usual organic solvents and is partially soluble in water, with which it forms an azeotropic mixture boiling at 90° C. It is soluble in 40-60% sulfuric acid from which it can be recovered by dilution with water. On heating with 48% aqueous hydrogen bromide trans-1,4-dibromocyclohexane is formed.

Studies on Some t-Butyl Homologs of Naphthalene, F. C. Whitmore and W. H. James, *Jour. Amer. Chem. Soc.* **65** (1943) pp. 2088-90.

The Friedel-Crafts reaction between naphthalene and t-butyl chloride in carbon disulfide solution at 0-5° C. gave a 45% yield of monoalkylated product. At higher temperatures the tendency is to form di-t-butynaphthalenes. The mono-t-butylnaphthalene obtained, boiling point 145° C. (15 mm.), 115° C. (6 mm.) $n^{20}D$ 1.5795; melting point —4° C., gave a picrate of melting point 100-101° C. and a quinone, melting point 76-77° C. The preparation of t-butylnaphthalene by the dehydrogenation of t-butyltetralin, or by the reaction between isobutylene and naphthalene, gave lower yields and lacked the simplicity of the direct Friedel-Crafts reaction between t-butyl chloride and naphthalene. The detailed procedure used in the various syntheses studied are presented.

Recent Developments in Nitroparaffins, H. B. Hass, *Ind. & Eng. Chem.* **35** (1943) pp. 1146-52.

Vapor-phase nitration, starting with the cheapest of all pure organic compounds, namely the hydrocarbons of petroleum and natural gas, gives rise through simple reaction sequences to the following classes of compounds: mononitroparaffins, dinitroparaffins, amines, diamines, alkylhydroxylamines, oximes, hydroxamic acids, carboxylic acids, aldehydes, ketones, halogenated nitro compounds, nitroalcohols, nitroglycols, nitroalkanetriols, organic esters of the three preceding type compounds, inorganic esters such as nitrates and phosphates, aminoalcohols, aminoglycols, aminoalkanetriols, aminoacetals, and soaps of the four preceding type compounds, nitro-olefins, and nitroketones. In 1935 an agreement was reached between Purdue Research Foundation and the Commercial Solvents Corporation by which the latter assumed the responsibility for placing these processes into commercial operation. Since vapor-phase nitration represented a wholly new technique, delays inevitably occurred while development problems were being solved. In May, 1940, the

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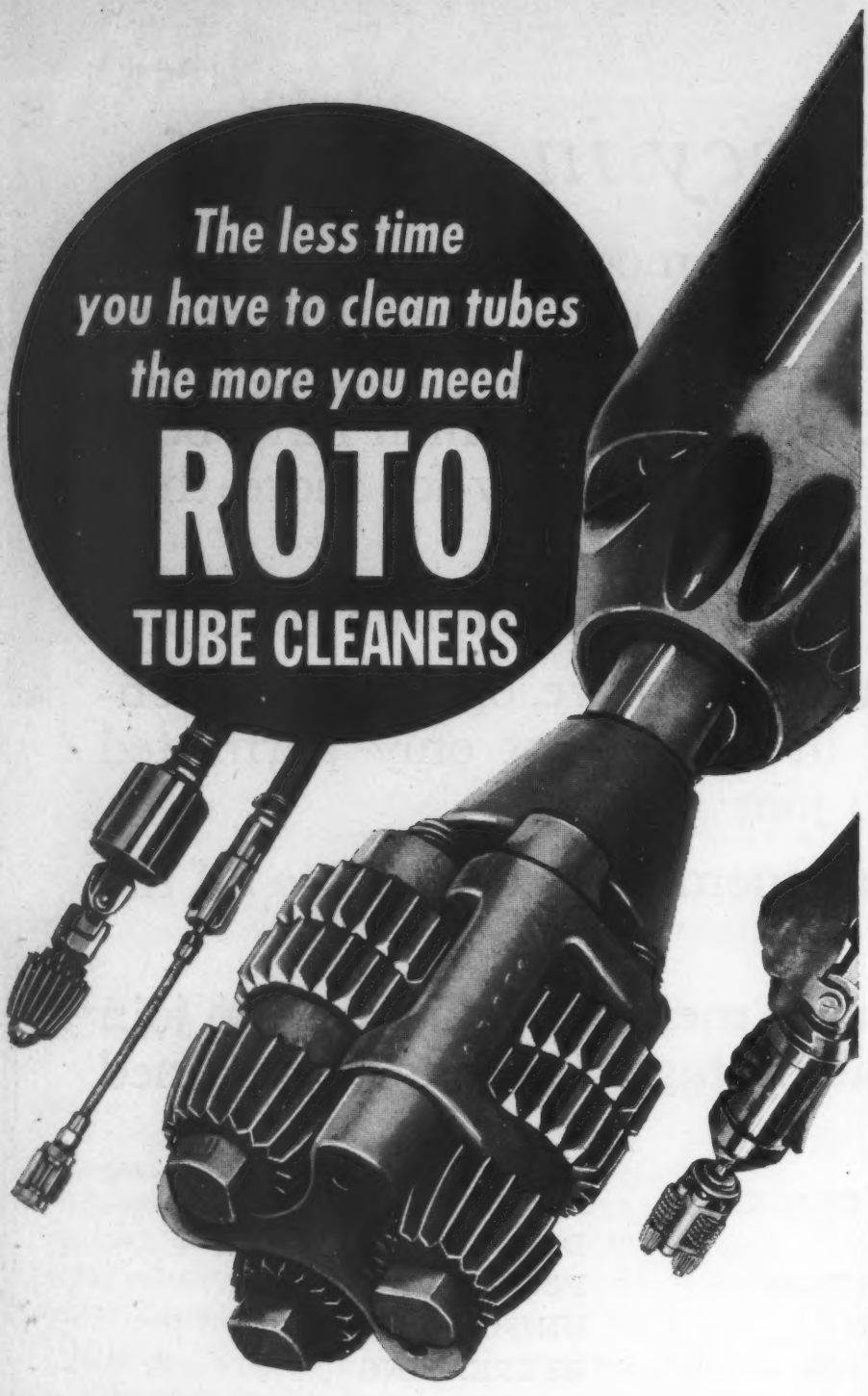

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first commercial-scale production of nitroparaffins occurred. When the war is over greatly increased facilities for the production of nitric acid will no longer be required for the manufacture of explosives; this will make possible the production of nitroparaffins on a scale limited only by the capabilities and ingenuity of American chemists. In the period 1900-1930 much work was done to find a practical way to nitrate the paraffins, but it was concluded that the reactions were slow and accompanied by oxidation. The early history of the development work at Purdue is reviewed, particularly that concerning the nitration of the butanes. Nitropentane yields nine nitroparaffins. The nitration of methane is described. The principal competing reaction in the nitration of the paraffins is oxidation of the hydrocarbon or nitroparaffin by nitric acid. The nitric acid is reduced to nitric oxide, which is cycled back to the nitric acid plant so that in the overall it is possible to obtain 60-90 moles of nitroparaffin for every 100 moles of nitric acid used. Nitroparaffins, in admixture with alcohol, are powerful solvents for cellulose nitrate, cellulose acetate, cellulose triacetate, cellulose acetate-propionate and acetate-butyrate. Mixed solvents containing nitroparaffins are the preferred ones likewise for Vinylite resins. Nitroparaffins are readily reduced to amines. These reactions are described and discussed. When a primary or secondary nitroparaffin is treated with a base and a halogen simultaneously, high yields of alpha halo derivative are produced. Condensation with aldehydes to yield nitroalcohols is the most prolific source of compounds derived from the nitroparaffins. This is illustrated by the addition of formaldehyde to nitromethane. Several other reactions are discussed by the author, as well as the application of the various products. A bibliography of 30 references is included.

Manufacture: Processes and Plant

Petroleum—Past, Present, and Future. PER K. FROLICH, *Ind. & Eng. Chem.* 35 (1943) pp. 1131-38.

The author reviews recent progress in the petroleum industry. Our growing dependence on the products of the oil industry has resulted in concern regarding the ability to supply future needs for liquid hydrocarbons. The proved reserves of crude oil correspond to approximately fifteen years' consumption at the prewar rate. However, the excessive wartime requirements have led to such a high rate of withdrawal from these underground reserves that we may not be able to meet the demand long. In addition to the known petroleum reserves, others can be present in the earth, and large, undiscovered resources can be expected to exist in various parts of the world. How long we can continue to find this oil and bring it to the surface at the desired rate is a question, but it is certain that eventually a shortage in natural petroleum will occur. When that time comes, it will be possible to supply our needs for gasoline and other hydrocarbon products from such alternative resources as natural gas, shale oil, and coal. The author concludes that there need be no sudden change as far as the supply and consumption of gasoline and other petroleum products are concerned. Further developments in the field will be

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Nomograph of Dittus-Boelter Equation, C. J. RYANT, JR., *Ind. & Eng. Chem.* **35** (1943) pp. 1187-88.

The Dittus-Boelter equation is regarded as the best practical expression for predicting the heat transfer coefficient of a substance in turbulent flow inside smooth pipe. Workers have sometimes shunned the use of this handy equation because it is necessary to use consistent units that are seldom found in the technical data. To avoid errors in conversion a nomograph of the equation has been prepared and corrected so it will be satisfied when a given system of mixed units is employed. These units are stated by the author. Using reasonable care in correcting the scales the author considers that a solution of the equation having an accuracy of ± 0.2 percent can be had. The nomograph can be used to solve for any variable in the equation.

Water as an Antidetonant, *Commercial Motor* **78** (1943) p. 162.

Water is known to be an efficient antiknock agent, a fact evident in that motors run better at night. The recent British patent 554,872, issued to Biske, concerns a method of making stable water-gasoline emulsion using a small percentage of water. The mixture is subjected to vibrations of every high frequency, between 100,000 and 1,000,000 cycles per second. Fifteen minutes of such treatment is claimed to convert a 95:5 gasoline-water mixture into a stable emulsion of good antiknock quality. Water-soluble compounds can be used as well as water.

Performance of Drip-Point Grid Tower Packings. III. Gas-Film Mass Transfer Coefficients; Additional Liquid-Film Mass Transfer Coefficients, M. C. MOLSTAD, J. F. MCKINNEY AND R. G. ABBEY, *Trans. Amer. Inst. Chem. Engrs.* **39** (1943) pp. 605-62.

Measurements of the rate of absorption of ammonia in water were made using the apparatus and nine industrial tower packings described in a previous paper (Trans. Am. Inst. Chem. Engrs. 38, 387-409). In tests at a constant water rate of 3000 lb./(hr.) (sq. ft.) the gas rates were varied from 100 to 1100 lb./(hr.) (sq. ft.). In tests at a constant gas rate of 500 lb./(hr.) (sq. ft.) the water rates were varied from 1800 to 18,000 lb./(hr.) (sq. ft.). The transfer coefficients, K_Ga, increase with increases in the gas rate or the water rate, and in most cases can be represented by

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straight lines on a log-log chart. The coefficient varies greatly with the packing; typical values, expressed as lb. moles/(hr.) (cu. ft.) (atm.), measured at G = 500 and L = 3000 lb./(hr.) (sq. ft.) are as follows: 1″ Raschig rings, 23.0; 1″ berl saddles, 19.8; wood grids with ½″ legs, 13.0; No. 6295 Drip-Point grid tile, 12.0; 3″ x 3″ triple-spiral tile, 11.8; No. 6146 and No. 6897 Drip-Point grid tile, 9.8 and 9.0, respectively; wood grids without legs, 8.4; 3″ x 3″ single-spiral tile, 8.2; and 3″ x 3″ partition tile, 3.8. Additional measurements of oxygen desorption rates gave values of the liquid-film coefficient, k_la, which are believed to be more accurate than those previously reported for these packings. With this knowledge of k_la it was possible for the first time to calculate the gas-film coefficient k_ga, and thus get a measure of the resistance to mass transfer which is due to each film. For most of the tests, at least 85 percent of the total resistance was in the gas film. The variation of K_ga with gas rate ranged from 0.4 to 0.9 power of the gas rate, depending on the packing. Similarly, the variation of k_ga ranged from 0.42 to 0.88 power of the gas rate, for the packings tested. This indicates that a single value, such as 0.8, cannot be taken for all packings, and that the exponent for any packing depends on the relative importance of laminar diffusion and transfer due to gas turbulence. The transfer rates are also expressed in terms of the height of a transfer unit $(H.T.U.)_{og}$. A plot of pressure drop per transfer unit, which is proportional to the pressure drop through a packed tower for a given duty, shows a 28-fold variation between the lowest, No. 6146 Drip-Point grid tile, and the highest, 1″ Raschig rings. For many of the packings, the pressure drop per transfer unit shows a minimum at a water rate of about 5000 lb./(hr.) sq. ft.). The prediction of overall coefficients for systems other than ammonia and water is discussed, but there are at present no comparable data through the use of which predictions can be tested.

Commercial Alkylation with Hydrogen Fluoride Catalyst, F. E. Frey, *Chem. & Met. Engr.* **50** (1943) pp. 126-8.

One of the important wartime developments in the field of aviation gasoline manufacture has been the anhydrous hydrofluoric acid alkylation process. In this method hydrogen fluoride is used as catalyst in place of sulfuric acid and joins paraffins such as isobutane with olefins such as butylenes to make isoparaffin blending agents. The author describes the operating features of the first commercial HF alkylation plant, which has been in production for almost a year. Wartime secrecy prevents disclosure of more details at this time. A generalized flowsheet is presented, together with a brief description of the plant including instrumentation, materials of construction, catalyst consumption and safety practices.

Materials of Construction for Anhydrous Hydrofluoric Acid, C. M.. Fehr, *Chem. & Met. Engr.* **50** (1943) p. 129.

Anhydrous hydrofluoric acid, a new oil refining chemical, has recently attained the status of a large tonnage commodity. As with any new substance, users are concerned with questions of handling, storage and use. The answers to many of these are abstracted in the author's article. Mild carbon steel is

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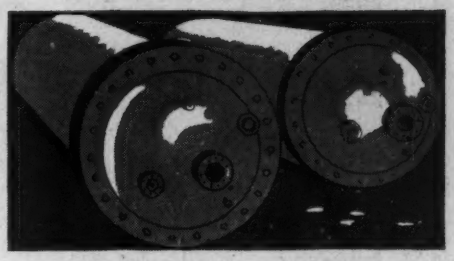
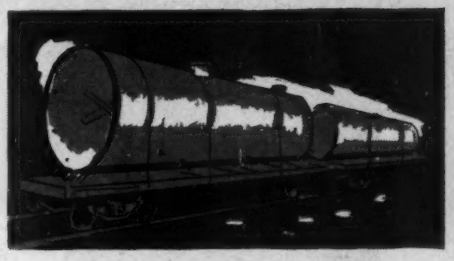
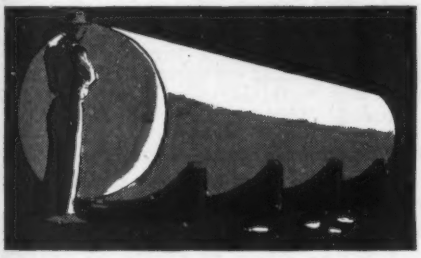


2. AUTOCLAVES



3. ISO BUTANE REFLEX DRUM



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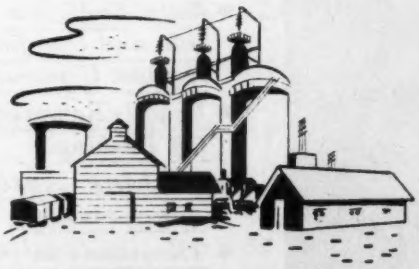

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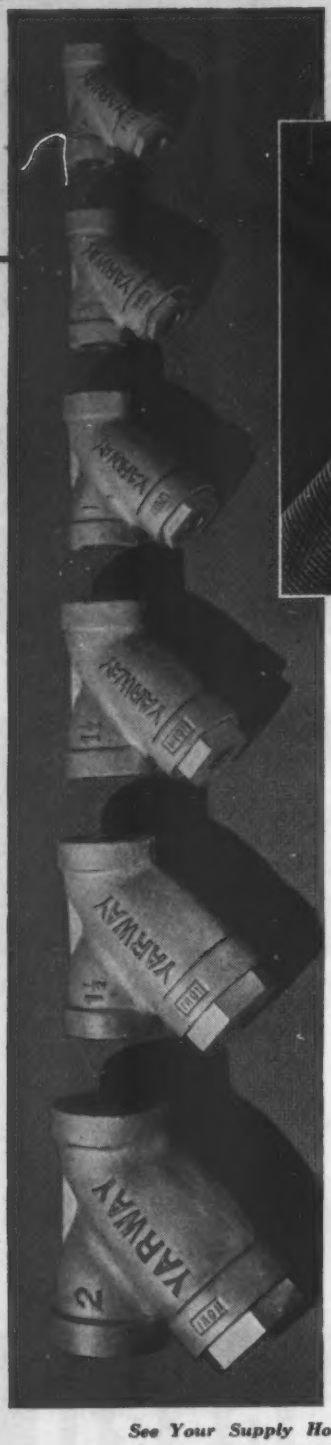

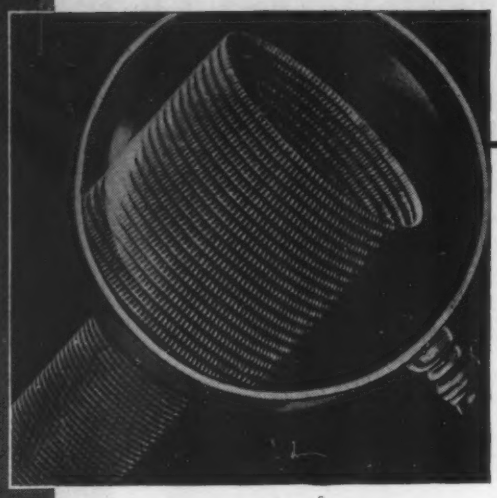

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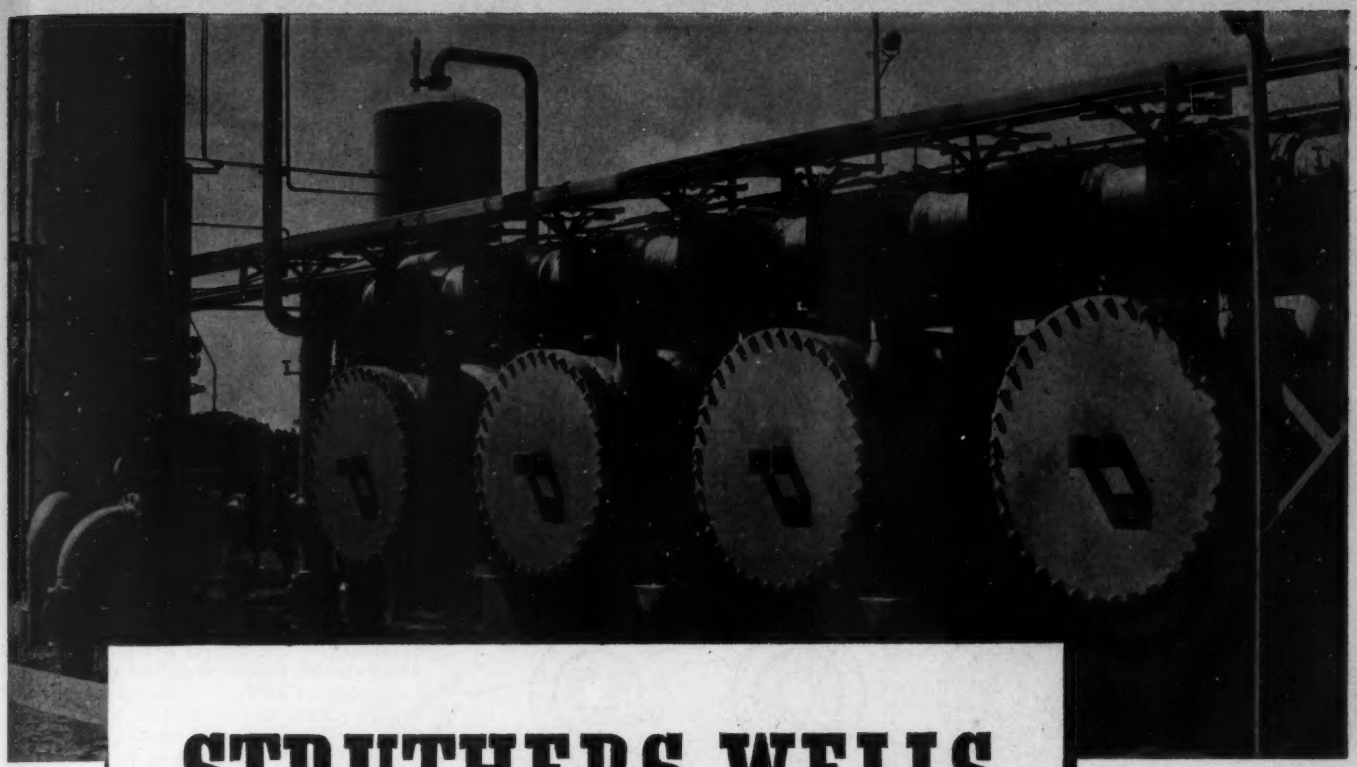
excellent for handling anhydrous hydrofluoric acid and is the logical material for storage tanks, pipes, fittings, valves, and pumps. This conclusion has been sustained by experience during a twelve-year period and it can be positively stated that steel tanks for storing HF have been in service for ten years and are in good condition today. The shipping container problem has been solved by the use of steel. A protective coating forms on the surface of the steel, inhibiting further corrosion. Extra heavy seamless steel pipe and forged or cast steel fittings are preferable for handling HF. Welding makes the ideal joint, provided the weld is homogeneous and free from slag and oxides. Welded fittings should be used wherever possible. If threaded joints are used on small pipe, the threads must be carefully cut, pulled tight and seal welded. For pipes larger than 2-inch, ring flanges with soft iron or copper gaskets are satisfactory. Wherever application permits, needle or globe valves are preferable to gate valves due to their sturdy construction.

Re-refining of Aircraft-Engine Oils, G. K. Brower, *S. A. E. Jour.* **51** (1943) pp. 130-8T.

The author reviews seven re-refining processes for used aircraft-engine oils. The process used by the American Airline is emphasized. A mixture of used oil and activated earth such as Magnesol, Retrol, or fuller's earth, is heated to 475-600° F. under vacuum using steam stripping to remove dilution and moisture. A filter aid is then added and the mixture filtered. The filtrate is distilled under vacuum. Indiana and Underwood oxidation, oxygen absorption, bearing-corrosion tests, and physical-property determinations show the re-refined oil and the original or new oil to be substantially equal in value. Cost data are included. The wartime application of the re-refining processes is considered.

Catalytic Desulfurization of Gasolines by Cobalt Molybdate Process, A. C. Byrns, W. E. Bradley, and M. W. Lee, *Ind. & Eng. Chem.* **35** (1943) pp. 1160-67.

It is desirable to reduce the sulfur content to 0.01% or less in gasolines to be blended with tetraethyllead. There is a more or less gradual increase in lead susceptibility as the sulfur content decreases to 0.05%, but as it is decreased still further there is a relatively rapid increase in lead susceptibility which becomes marked in the region of 0.01% sulfur. The authors review three principal types of processes used for the removal of sulfur. Since no method appears to be available for the selective decomposition of all types of sulfur compounds without at the same time causing rather profound changes in the hydrocarbons present, an investigation was undertaken with the objective of developing such a process. An efficient process has been developed through the semipilot plant stage for catalytic desulfurization of gasoline fractions containing up to 3-4% by weight of sulfur in the form of organic sulfur compounds. The process is equally applicable to straight-run or cracked stocks. Thiophenes, as well as thiophanes, thioethers, and mercaptans, are decomposed to hydrogen sulfide and hydrocarbons. Products containing less than 0.01 percent sulfur can be obtained. The catalyst employed consists of co-



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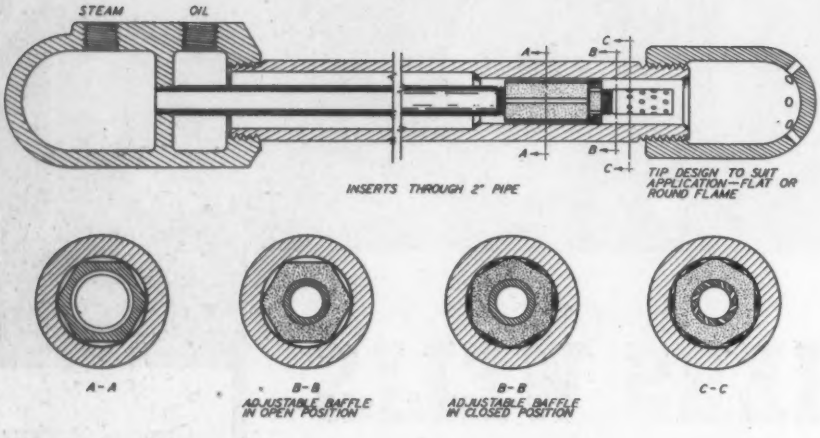

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balt molybdate, either as such or deposited on a carrier. Over 1500 liquid volumes of feed have been desulfurized by 1 volume of catalyst without regeneration and without detectable loss in activity. The catalyst can be regenerated repeatedly in the conventional manner and to its original activity. The apparatus and procedure used in the work are described and the data are presented in graphical form in considerable detail. A tabulation is also given showing the characteristics of feed stocks treated and of the resultant products. The data include distillation range, sulfur content, gum content, color, knock rating, and olefin content.

Economical Raising of Steam in Small and Medium-Size Boiler-Plants, G. W. HIMUS, *Trans. Inst. Chem. Engrs.* **19** (1941) pp. 33-44.

Although the principles underlying the efficient generation of steam in the small boiler-plant differ in no wise from those applied in the super-power station, their practical application in the small plant presents problems that are unknown to the power station engineer. The type of boiler installed depends on a number of factors, including: the output of steam required; the temperature and pressure of the steam; the load, whether highly variable or fairly steady; the general conditions of working, whether one, two, or three shifts; the fuel available and its price; the class of labor available; and the character of the feed-water. A table is given that summarizes the characteristics of the chief classes of boilers. From the point of view of management, the best fuel is that that enables steam to be produced at minimum cost. A table is given summarizing the properties of the fuels available for steam-raising. Boiler plant auxiliaries such as feed-pumps, mechanical draught equipment and superheaters are briefly discussed. The subject of control instruments is reviewed. Tables are given showing the comparison of the methods of firing steam boilers with solid fuel including hand firing, underfeed stokers, sprinkling stokers, traveling grate stokers, and pulverized coal. A table is included showing the effect of excess air in relation to its place of entry. It is pointed out that the terms efficiency and economy are not synonymous. A curve of efficiency versus economy is presented. This comprises three parts: (1) a straight line representing the gain in efficiency that is obtainable without any appreciable modification in the plant but merely by improvements in the general methods of working; (2) a curve of decreasing slope, the commencement of which represents the point at which increased efficiency can only be secured by improvement in the plant, demanding the expenditure of capital; and (3) a falling curve which falls slowly at first, but more and more sharply as the efficiency increases. The financial saving arising from increased efficiency is offset by the extra cost involved in effecting the saving. The optimum thermal efficiency is obviously that at which the economy curve attains a maximum.

Products: Properties And Utilization

Propane Plant Helps Meet Peak Load Demands, F. D. HOWELL, *Gas Age* **92** (1943) p. 13.

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ural Gas Company in the use of propane for peak gas loads is described. The experiments indicated that a mixture of propane and air of 1120 B.t.u. would be satisfactory if used alone or in combination with natural gas in any proportion. The storage problem was solved by using 2 miles of 24-inch 9/32-inch thick wall seamless tubing. Twenty-six tanks, 425 feet long, were made by electric welding. Tanks were laid in wood cradles embedded in concrete, below the frost line. Kettle-type heat exchangers containing two sets of coils were used for vaporization. Comparatively few appliance adjustments were found to be necessary. Although the plant was used for peak load only, it produced 120 million cubic feet of propane-air-gas mixture in 1942. The plant can be brought from complete standstill to full operation in approximately 45 minutes.

Radiosulfur Tracer Study of Sulfurized Lubrication Addition Agents, G. L. CLARK, S. G. GALLO AND B. H. LINCOLN, *J. Applied Phys.* **14** (1943) pp. 428-34.

Radioactive sulfur of a half-life of 88 days was made in the cyclotron from carbon tetrachloride by the reaction ${}_{17}Cl^{35} + {}_{0}n^{1} = {}_{16}S^{35} + {}_{1}H^{1}$. The sulfur was furnished as barium sulfate, reduced to free sulfur, mixed with inert flowers of sulfur, and added to an olefin of iodine number of 100 mixed with 3 times its weight of a neutral oil. The blend used contained 0.15% added sulfur and gave a negative copper-strip test. Film formation was tested on 7 different kinds of commercial bearings and on glass, the rates of formation being measured at 88° C. and 25° C. Films are formed more slowly at the lower temperature, but still with sufficient rapidity for satisfactory engine protection. The mechanism of inhibiting oxidation is discussed.

A Modification of the C.F.R. Bouncing Pin Spring-Tension Balance and Instructions for Use, P. DRAPER, *Jour. Inst. Petr.* **29** (1943) pp. 253-7.

The spring-tension balance designed in the Shell Laboratories and described in the Journal of the Institute of Petroleum, Vol. 28, p. 209, proved so successful, particularly in enabling repeatable octane ratings to be obtained in the range of 90-120, that the Institute of Petroleum requested the C.F.R. Committee in America to cooperate by designing a less costly apparatus. This has been done very successfully by the Ethyl Gasoline Corporation Yonkers' Laboratory, and the instrument is described in this report. It has certain advantages over the original model.

Clearing House Service for Consultants Available

The Association of Consulting Chemists and Chemical Engineers, 50 East 41st Street, New York, has organized a service which is called "Clearing House for Consultants." Purpose of this service is to bring together consulting engineers in the fields of chemistry, engineering and related branches, and the companies needing such service. Anyone in need of a consultant's advice will be given information readily and will be referred to properly trained men. A classified directory of the association is available on request, without charge.

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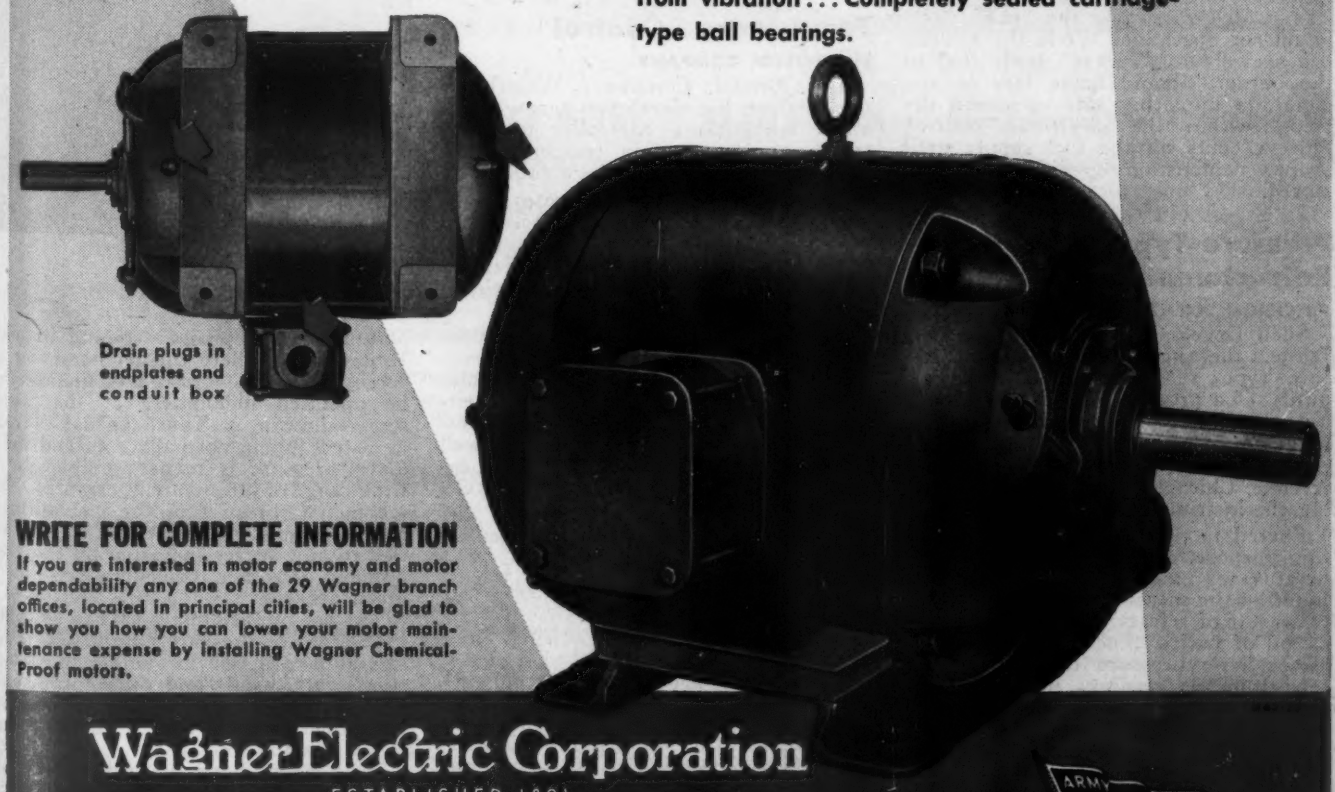

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Combustion Control Corporation, Cambridge, Massachusetts, announces "Fireye" Type F28C, a photoelectric system for providing instantaneous fuel cut-off in any pressure-fed burner in the event of flame failure.

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The outfit is used with manually ignited burners to cut off fuel and sound an alarm; or, when the burner is automatically fired, with Program Relay Type R25, to program fuel pump and valve operation, intermittent ignition system, purging period, and recycling.

Designed to operate at relatively high ambient temperatures, Type F28C is mounted directly on the furnace wall and watches the flame through a window in the wall of the fire chamber. Once the lens of the optical system has been aligned, the field of vision of the electric eye is limited to the flame itself and extraneous light is rejected. Light from the flame strikes the sensitive plate of the photocell and starts a flow of electrons, producing a minute electrical current. After passing through a vacuum tube, this current is amplified sufficiently to operate a relay which directly controls a solenoid valve governing fuel feed, or "Fireye" Program Relay Type R25, which programs the entire cycle of burner operation. While the electric eye sees flame, "Fireye" feeds fuel to the burner. Should flame fail, or any condition impairing safe operation develop within the electronic control, "Fireye" cuts off the fuel supply until proper combustion conditions are restored.

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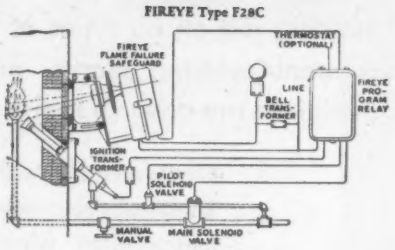

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Pressure-Type Refractometer

PRECISION SCIENTIFIC COMPANY

Shell Development Company has developed the Shell continuous flow, pressure-type refractometer to indicate purity of a product as it flows through a processing pipe line, for application to manufacture of butadiene. Precision Scientific Company, 1750 N. Springfield Avenue, Chicago 47, Illinois, is marketing the instrument.

Forced to develop an instrument for this purpose, since no commercial apparatus was available, a solution was found in the measurement of the physical factor of refractive index as an indication of purity. Since butadiene under atmospheric pressure boils at 19° C., refractometric readings must be made either under pressure or at decreased temperature. With this new instrument, readings are taken at the pressure at which butadiene is produced.

The instrument embraces a refractometer, with dipping prism mounted in a pressure cell through which the liquid, the index refraction of which is to be measured, flows continuously under the pressure existing in the process flowline, while being maintained at constant temperature. Both pressure and temperature maintained within the instrument are adjustable to meet individual installation requirements and applications to various liquids.

Temperature Control

THE BRISTOL COMPANY

The Bristol Company, Waterbury, Connecticut, has developed a new automatic temperature controller for controlling polymerization temperature in the manufacture of synthetic rubber.

This instrument incorporates in a single unit all the equipment needed to automatically control the temperature in polymerizers used for polymerization of butadiene and copolymers such as styrene or acrylonitrile.

The instrument automatically controls the complete polymerization process, including heating and cooling cycles and is designed to eliminate overshooting of the control point as the temperature reaches the control setting as well as control the temperature at the desired value during the reaction cycle.

The instrument is a recording air-operated controller designed particularly for polymerizer reactors.

Radiation Unit

THE BRISTOL COMPANY

The Bristol Company, Waterbury 91, Connecticut, has designed a fixture adapting their new radiation unit to the measurement of stove dome temperatures. The fixture consists of a gate valve to enable the unit to be removed for service and an air purge to cool the lens and unit.

The radiation unit is used in conjunction with the company's new Pyromaster Potentiometer Pyrometer.

Pipe Lining

BALDWIN-HILL COMPANY

Baldwin-Hill Company, Trenton, New Jersey, has developed an insulation which enables carbon steel pipe of ordinary weight and construction to successfully handle the high temperatures in the manufacture of 100-octane gasoline and synthetic rubber. The material is known as Insidline.

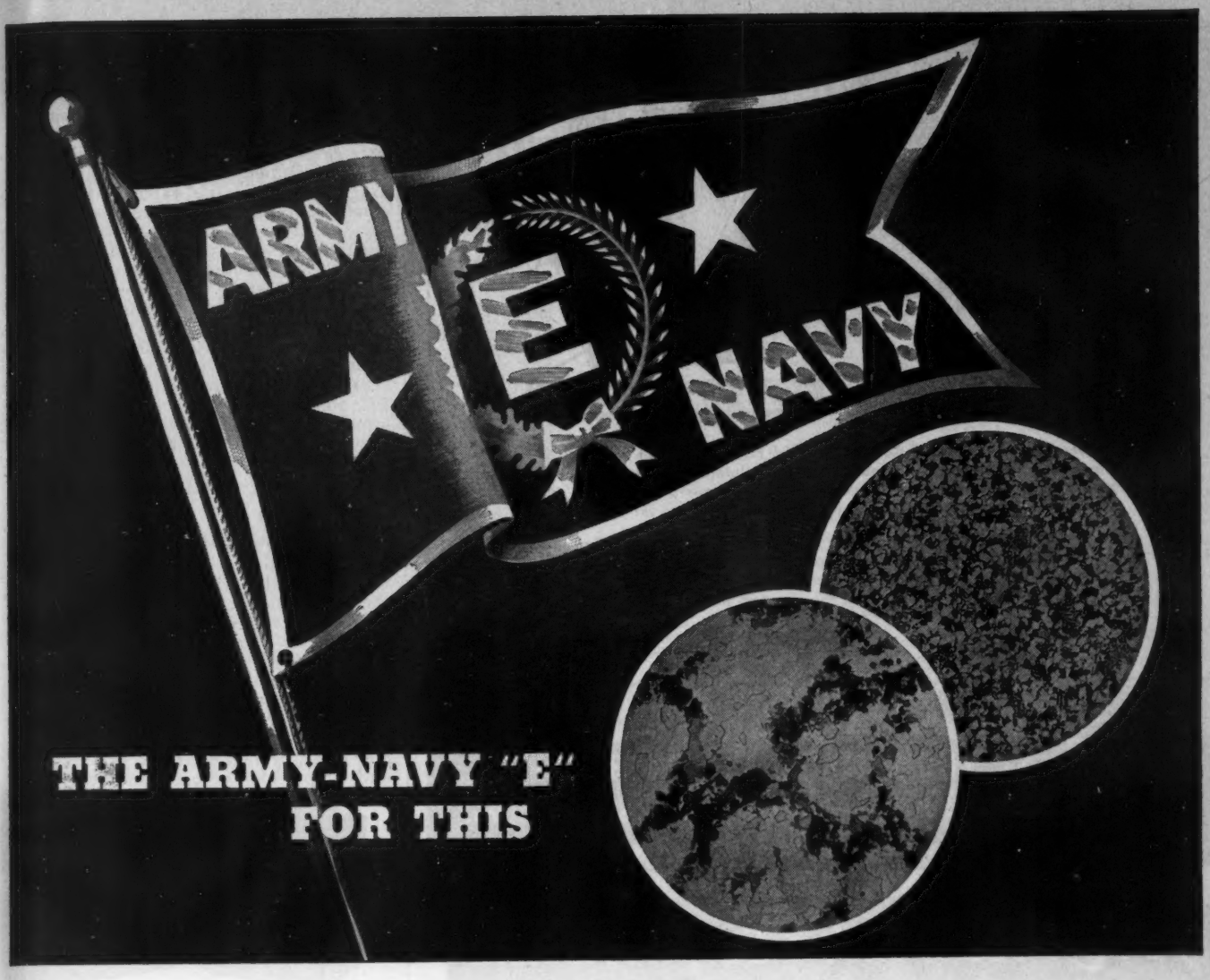
Insidline construction consists of a layer of high-temperature-insulating material placed against the inner surface of the pressure piping. The insulating material is a felted block with a diatomaceous-earth base reinforced with amosite asbestos fibres. It is retained and protected by metal liners so arranged as to provide adequate expansion clearances with a minimum of heat flow through the metal. The inner liner is not required to resist pressure and is therefore not made pressure tight. It is only slightly stressed by its own weight, the impact of high velocity gases and the negligible weight of insulating material. Its composition and thickness can be varied to meet conditions of temperature, corrosion, erosion and velocity encountered in various installations.

The primary objective of the internal insulation and lining is to hold the temperature of the pressure piping to 650° F. or below, where the phenomenon of "creep" does not occur and metals can be operated indefinitely at the usual stress allowances. Thus, the use of carbon-steel piping normally specified for a given pressure is made possible for a wide range of internal temperatures. The secondary objective of the insulation is heat conservation, and this can be carried to any degree indicated by the economics or other considerations in a given process.

Insidline

The use of Insidline is said to simplify the design of pressure piping with considerable reduction in number of expansion joints, bends and other provisions for pipe expansion. Resulting weights are reduced with saving in supports and other structural details.

Insidline applications have been made for flue gases, steam, petroleum gases, hydrogen and fluid catalysts for pressures up to 300 pounds and temperatures up to 1500° F. in various combinations. These conditions have necessitated installation of Insidline in pipe sizes



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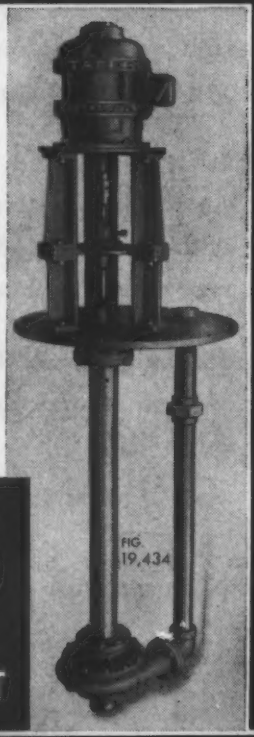

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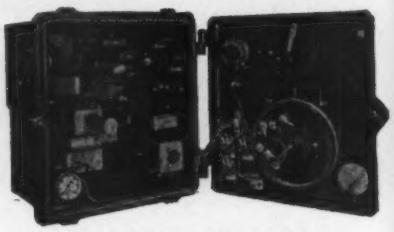


Tag Celectray Pneumatic Indicating Controller

The mirror galvanometer and photoelectric amplifier are here combined with a pneumatic follow-up. The output air is precisely and stably controlled to provide the utmost in performance according to the inherent possibilities lying in ordinary throttling control with manual reset or with automatic reset. On-and-off or open-and-shut control is available in two models, high sensitivity, non-adjustable throttling or on-and-off without throttling.

In this instrument in place of the relay found in older models, there has been substituted a magnetic air-valve which acts as an amplifier and converter from electric to pneumatic operation.

The light beam "follow-up" flag is moved back and forth by changes of the air pressure in the bellows of the "follow-up" assembly unless the sensitivity-adjusting arm is turned to the highest sensitivity on its scale. With this adjustment, the throttling range is zero, the flag stands still as the control pressure varies and the controller acts as an on-and-off or open-and-shut controller, opening or closing the valve to its limits for small changes in temperature, for example. Now as the temperature varies, the light image moves across the controlling edge of the flag and more or less of the light reaches the phototube. More light on the phototube causes more current to flow through the magnetic

WHITLOCK

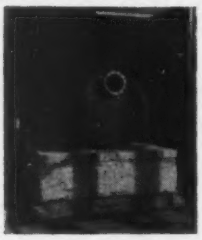
HEAT TRANSFER EQUIPMENT

BUILT WITH **MODERN** FACILITIES

AUTOMATIC HEAVY WELDING MACHINES

High ductility, soundness and strength of welds are insured by these precision control machines.

ANNEALING AND NORMALIZING FURNACE



The need for equalizing the structural conditions throughout the work and the necessity for relief of internal stresses are recognized; this furnace satisfies these requirements.

METALLURGICAL X-RAY EQUIPMENT

Determines the true quality of a weld and guarantees the strong, dense welded seams which assure the safe operation of Whitlock Heat Exchangers under high pressures.

The combination of such equipment and Whitlock's engineering "Know How" provides the answer to your heat transfer equipment problems.

The **WHITLOCK**
MANUFACTURING COMPANY
75 South St., Elmwood, Hartford 1, Conn.

Branch Offices: New York, Boston, Chicago, Philadelphia, Detroit, Richmond — *Authorized representatives in other principal cities — consult local telephone directory under our name.*

Whitlock Equipment (Whitlock—Darling) is manufactured in Canada by Darling Brothers, Ltd., Montreal

Extreme Temperature Shocks? Pyrex Brand High Pressure Gauge Glasses can take them

PYREX brand High Pressure Gauge Glasses can take the shock of sudden temperature changes that would instantly shatter an ordinary glass. In fact it is routine test for these gauge glasses to be heated up to 425°F. and then plunged into ice water. Will they ever have to meet such severe tests in your service?

And just as resistant as they are to thermal shock, PYREX brand High Pressure Gauge Glasses are also highiy resistive to the solvent action of steam and hot water. This means that they retain their clear visibility. Their hard smooth surface and rugged strength enable them to stand up better under rough physical handling and make them less liable to become scratched.

Yes, you can expect and you will get an exceptionally long life from PYREX brand High Pressure Gauge Glasses.

Where other conditions prevail, you can select the right gauge glass that best meets your requirements from the complete line of PYREX and CORNING brand Gauge Glasses listed below. You will find that every one of them will fill your particular needs in long, value-giving service.

PYREX brand High Pressure—resistant to thermal and mechanical shock and attack of steam and hot water. Machine drawn accuracy.

PYREX brand Red Line—Same but with added visibility afforded by enameled red line.

PYREX brand Broad Red Line—Same but with fused in broad red line for extra visibility.

Corning Standard—For moderate pressures.

"Pyrex" and "Corning" are registered trade-marks and indicate manufacture by Corning Glass Works.

CORNING Glass Works Corning, New York

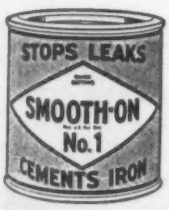
Pyrex Gauge Glasses

This crack, between the air starting valve port and the cylinder head water jacket of a Diesel engine, seemed impossible to repair.

However, the ingenious engineer simply fitted a pipe sleeve into the port, filled the crack with SMOOTH-ON No. 1, also applying a thin coat of SMOOTH-ON No. 3 to cement the sleeve in place. The repair was speedily made and has proved entirely satisfactory.

When you are up against a crack or break in a machine casting, or a leak at a joint of any kind, or a loose part of a fixture, think first of SMOOTH-ON. This many-purpose iron repair cement will frequently enable you to make repairs quicker and at less cost than by any other method.

Buy SMOOTH-ON in 7-oz., 1-lb., or larger containers from your supply house, or if necessary, from us. For your protection, insist on SMOOTH-ON, used by engineers and repair men for over 49 years.



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REPAIR HANDBOOK SHOWS HOW

40 pages, 170 diagrams, and simple concise instructions for practical repairs to plant equipment, pipe lines and structures. A necessity in every plant. Your copy sent FREE if you fill in and return the coupon.

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Do it with **SMOOTH-ON**
The Iron Repair Cement of 1000 Uses

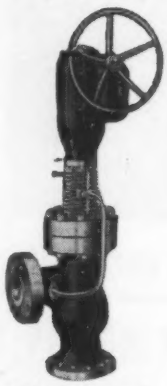
air valve. This in turn draws in the armature, moving the orifice tongue closer to the orifice in the block and raising the controlled air pressure. Less light on the phototube thus lowers the controlled air pressure by decreasing the current to the magnetic air valve.

If the sensitivity is lowered by moving the arm to a lower value on the scale, then the flag will follow the light beam as it moves back and forth with changes of temperature. The flag will follow to the limits of the throttling zone as determined by the position of the arm.

Manual Control Valve

FISHER GOVERNOR COMPANY

Fisher Governor Company, Marshalltown, Iowa, has announced the new Fisher Manual Control Valve, for dependable throttling control for all liquid, gas or steam service. The valve is recommended especially on installations where high pressure drops or other severe operating conditions are encountered.



Fisher Manual Control Valve

Features include single-seated, plug type, stainless-steel, chromium-plated inner valve. Flushing connection prevents formation of coke deposits. The extra heavy top work assembly combines heavy load-carrying ability with ease of operation. Accurate valve positioning adds to the efficiency of the assembly.

The valve can easily be converted to automatic diaphragm control which provides an automatic control unit with manual over-rider.

Electronic Level Indicator

TRIMOUNT INSTRUMENT COMPANY

Trimount Instrument Company, 37 W. Van Buren Street, Chicago 5, Illinois, has developed an electronic level control utilizing electronic principles. The device is designed to maintain the level of any liquid or electrically conducting solid within an open or closed tank, bin, hopper or other container. The level is indicated by signals, or the control can

Electric Level Control

Refining Towers

Special Offering

Located Tulsa, Oklahoma

1 4′ 3″ x 40′ x 5/16″ type A-51-141 Burrell-Mase absorber, serial No. 153-75. Welded throughout; 14 bubble trays with 6″ cleanout flanges for each tray. 2-18″ manholes in shell. 80 lb. working pressure.

1 6′ x 43′ including 3′ skirt x 5/16″ cracking coil separator. Vessel is riveted, butt strapped and welded. 1-16″ manhole in top head and 1-16″ manhole in bottom of shell.

1 6′ x 21′ including 2′ 9″ skirt x 3/8″ Southwestern still. Vessel riveted and butt strapped. 1-16″ manhole in top head, 1-16″ manhole in bottom of shell.

1 30″ x 30′ including 2′ skirt x ¼″ welded tower. 10-6″ couplings welded in shell.

1 3′ x 33′ including 2′ skirt x 3/16″ welded tower. 12 trays.

1 3′ 6″ x 15′ including 2′ skirt x 3/16″ welded tower. 4 trays.

1 5′ x 28′ including 34″ skirt x ¼″ riveted tower. 18″ manholes in top and bottom.

1 7′ x 22′ x ⅜″ shell, ⅝″ heads riveted, butt strapped and welded tower. 21′ manway in top, 30″ manway in bottom. Seven 20″ x 25″ manways in shell.

1 5′ x 28′ x ⅜″ welded flash tower. 2-18″ manholes in shell. 4″ flanged outlet in top. 3″ screwed outlet in bottom.

1 22″ x 11′ 8″ x ⅜″ welded surge drum. 2-2″ couplings and 1-1″ coupling welded in shell.

1 10′ x 22′ 4″ including 8′ skirt x ⅜″ riveted agitator. Steel walkway 2′ 10″ wide with 5/16″ floor plate. 2 holes in walkways; one 24″ x 28″ and one 18″ x 20″. Capacity of agitator 9,080 gallons.

1 3′ 6″ x 20′ 6″ including 3′ 6″ skirt x ¼″ welded flash tower. 3″ outlet in bottom, 4″ outlet in top. 1-4″ and 2-3″ outlets in shell. 2-18″ manways in shell.

1 3′ x 14′ x ½″ riveted shell. 18″ manway in one end, 6″ coupling in shell.

1 72″ x 59′ 2″ x ¼″ Tulsa type fractional absorption tower. 1-12″ flanged nozzle in top head, 2-12″ flanged nozzles in shell. Also 2-4″ flanged nozzles in shell.

1 5′ x 44′ x 5/16″ riveted tower.

1 40″ x 18′ x 5/16″ Braun still. Vessel welded throughout. Working pressure 30 lbs.

1 6′ x 42′ x ½″ flash tower, 3′ skirt, equipped with 2″ coils.

2 7′ x 35′ x ½″ gray filter towers, 16′ skirt, riveted construction.

3 60″ OD x 44′ long x 4″ thick Krupp manufactured cross reaction chambers.

Located Stark (near Detroit) Michigan

1 Vis-Breaker Tower, 4′ x 64′ x ⅜″ thickness, welded construction. Four steel perforated pans in lower section of vessel, 22 steel bubble trays with 38 caps per tray, 26 downcomers.

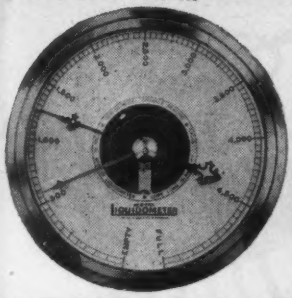
1 Vacuum Tower, 5′ and 4′ x 36′ x ¼″ shell thickness x 5/16″ head thickness. All welded construction, fabricated by the Muskogen Boiler Works. There are 4 trays in the upper portion of the vessel and two trays in the lower portion, there are approximately 70 caps per tray. The top section of the tower is 5′ in diameter for 21′ tapering 2′ to a 13′ section 4′ in diameter.

1 Vis-Breaker Accumulator, 3′ 6″ x 8′ x 7/16″ shell and head thickness, top head dished and bottom head cone. Riveted and welded construction.

Refinery Equipment, INC.

UNION AVE. AT 21st STREET
TULSA, OKLA.

THOSE WHO CAN'T AFFORD TO MAKE ERRORS IN MEASURING VALUABLE STORED LIQUIDS CHOOSE—



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100% automatic.

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Models available for either remote or direct readings.

Accuracy unaffected by specific gravity of tank liquid.

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A faster, cheaper and better method that thoroughly cleans the stubborn, greasy dirt from refinery equipment. Hot water at 190° combined with a solvent softens the dirt . . . high pressure tears it away . . . a volume of 1000 gallons per hr. washes dirt clear of work . . . An investment that pays dividends from the start.

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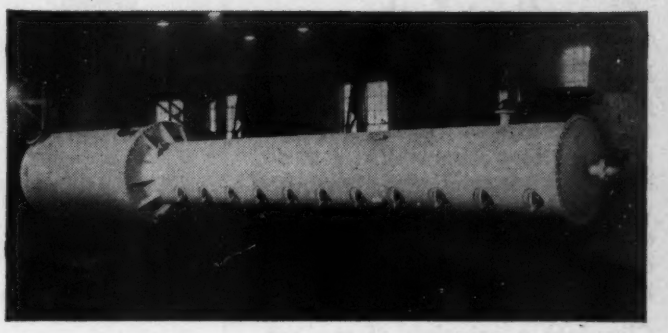
SPECIAL EQUIPMENT

for Chemical and Petroleum Plants



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Experienced engineers and modern facilities assure the right equipment for your requirements. We design and build, or fabricate to your specifications:

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Heat Exchangers	Storage Tanks
Pressure Vessels	Blow-Off Tanks

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Easier, Faster Way to Clean Heat Exchangers

Is cleaning condensers, coolers, preheaters or other heat exchangers a big maintenance problem in your refinery? If so, here's a successful short cut that will help you solve it effectively, easily . . . help you shorten down-time and put units back into service quickly!

Circulate a solution of the recommended Oakite de-scaling or cleaning material through fouled equipment as directed. You will find that most types of insulating water scale or carbonized oil deposits ordinarily encountered are THOROUGHLY yet SAFELY removed. Normal heat transfer efficiency of equipment is restored . . . you save time and conserve man-power!

Write for FREE Data!

Helpful data on this and such other maintenance work as washing drums, stripping paint, and salvaging pipe bends is yours FREE for the asking. Write today!

OAKITE PRODUCTS, INC.
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Technical Service Representatives Located in All Principal Cities of the United States and Canada

be installed to operate solenoid or motor-driven valves, pumps, lights, bells, or other electrical devices.

The control is non-mechanical and has no moving parts. It can be installed in evaporators, freezers, boilers, or other containers involving extreme temperatures.

Spotlight for Welding

GENERAL ELECTRIC COMPANY

General Electric Company, Schenectady, New York, has developed a new spotlight designed to provide glareless illumination of sufficient intensity for an arc-welding operator to see his work distinctly through the dark lens of a welding helmet prior to striking the arc.

This new spotlight is especially desirable for welding in which the establishment of the arc must be made quickly and accurately, such as in the welding of thin materials, light alloy castings, etc.

GE Welder's Spotlight

Fatigue is reduced through use of the spotlight also, since it is not necessary for the operator to lift his helmet before striking the arc. Spoilage of exacting work is also cut down because the operator can strike the arc precisely where required.

Mounted on an upright, telescoping metal standard and set firmly in an 18½-inch diameter, 30-pound cast iron base for stability, the spotlight consists of three 300-watt reflector spot lamps surrounded by a circular shade. Rated to give 1000 hours of continuous operation at 120 volts, the lamps are mounted in adjustable porcelain holders, so that the area covered by the light beam can be increased from a single, sharp spot 7 inches in diameter to a clover leaf shaped pattern approximately 17 inches across at its widest point.

The light can be raised or lowered on its standard, and held securely in place by a locking thumb screw, to any point from 45 to 76 inches above the base. A universal, friction ball-joint between the shade and the upright standard permits the light beam to be directed and held at any angle downward between vertical and 30 degrees below horizontal.

Controlled by a foot-operated switch which is depressed by the operator while the arc is struck, the unit is equipped with a 10-foot, oil-proof, heavily jacketed cable, with plug for connecting the light to the electric circuit. Except for the inside telescoping section of the standard, the entire unit has an attractive black crackle finish, and is furnished completely wired and ready for operation.

...THE PUMP VALVE WITH 1000 SEATS

Royal Crown PUMP VALVES offer new standards of service in refinery and pipeline pump installations.

Unlike other valves, the Royal Crown is a ball-guided spherical valve that revolves, swings and takes a new seat at each stroke of the pump. Not one, but a thousand seats are designed into the Royal Crown to make it wear longer, give greater efficiency.

The Royal Crown has all the advantages of the ball valve without its disadvantages—the R. C. is machined to a true balance; is lighter and more buoyant. Extreme temperatures or pressures cannot reduce its efficiency.

A wide range of sizes for either thread-or press-fit is available in any alloy metal. Write for catalog or seeyour dealer.

Howard Supply Co., Calif.
L. B. Stanley, Houston, Texas

MADSEN IRON WORKS
HUNTINGTON PARK, CALIFORNIA

POWER TO LIFT A TANK in the palm of your hand!

★ It weighs less than 4 pounds. It's so compact you can hold it in the palm of your hand. But it delivers enough pressurized power to lift a General Sherman tank. That's the amazing, new PESCO Pressure-Loaded Hydraulic Pump!

Never, until PESCO engineered it for modern aviation, was there so small a pump of equal displacement capable of delivering 3000 p.s.i. Radical improvements in design plus precision manufacture of the highest order are the ingredients.

Through PESCO design, entirely new opportunities are opened up for the more practical and efficient use of hydraulics in your product or plant. And that goes for controlled liquid flow as well as pressurized power. For PESCO's advanced design and performance extends through a complete line of hydraulic, pneumatic, vacuum and fuel pumps and pumping systems. Practically without exception, the precision equipment PESCO makes has been engineered to specifications of performance never dreamed of before modern aviation.

We would welcome the opportunity to tell you of our facilities to engineer PESCO equipment to meet your own specific problem. PESCO Engineering Service is available to you. Just write.

SEND FOR THIS BOOK "Pressurized Power and Controlled Flow by PESCO". This book pictorially tells the story of PESCO equipment, manufacturing facilities and engineering service. A copy will be mailed promptly upon request.

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Fire cannot burn without air. With swift efficient action C-D/Fog completely surrounds fire with a blanket of carbon dioxide. *Air is sealed out.*

C-D/Fog is especially recommended for oil, gasoline, electrical, or chemical fires. Built by General Detroit, manufacturers of fire protection equipment since 1905, C-D/Fog comes from a distinguished line of fire fighters, including such famous names as Fire Guard, Alaskan, and Floafome. Like all General products, it is quality mass produced for prompt delivery to essential users.

Find out about C-D/Fog today! Mail the coupon and details will be rushed!

THE GENERAL DETROIT CORP.

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Just attach this convenient coupon to your letterhead and mail.

☆ BUSINESS NOTES ☆

Asbestos Companies Merge And Will Expand Facilities

The Asbestos Fibre Spinning Company, North Wales, Pennsylvania, has been purchased by Greene, Tweed & Company, New York, manufacturer of Palmetto and other self-lubricating mechanical packings and also various mill supply specialties.

The positions of both companies in the asbestos field will be strengthened by this consolidation, it was said, and plans are now being made to enlarge the facilities and expand the operations of both companies.

Reeves Appointed Advertising Manager for Timken Company

Paul Reeves has been appointed advertising manager for The Timken Roller Bearing Company, Canton, Ohio, to succeed R. P. Kelley, resigned. Reeves attended Staunton Military Academy and is a graduate of Carnegie Institute of Technology with a degree in Mechanical Engineering. He joined The Timken Roller Bearing Company in 1929 and after completing the company's engineering training course served as sales engineer at Chicago. He subsequently was made industrial district manager of the company's San Francisco branch. In 1940 he returned to Canton as sales promotion manager, but when this country entered the war, he was put in charge of government priorities to handle contracts between the company and Washington.

Moore in Charge of New Pittsburgh Equitable Office

C. C. Moore has been placed in charge of the recently opened Atlanta, Georgia, office of Pittsburgh Equitable Meter Company-Merco Nordstrom Valve Company. The offices are located at 411 Bona Allen Building, Spring and Luckie Streets. Moore has been manager of the Memphis, Tennessee, office which has been closed. All southern operations of the company formerly cleared through Memphis, will now be handled through Atlanta.

Mobilift Lift Truck Opens Branch Office in Atlanta

Mobilift announces the opening of a new branch store at 107 Walton Street, N.W., Atlanta 3, Georgia. The branch is under the direction of E. P. Sells, and will provide service for southern users of Mobilift motor-driven lift trucks.

Ralph L. Wilson Becomes Timken Chief Engineer

Ralph L. Wilson, former chief of the constructional steels section of the metallurgical and conservation branch, steel division, of the War Production Board in Washington, became chief metallurgical engineer of The Timken Roller Bearing Company, Canton, Ohio, January 1.

Wilson, 44, is a graduate of Central High School, Canton, Ohio, and of Lehigh University, 1921, where he received the degree of Electrometallurgist.

His experience includes 6 years with the metallurgical departments of the United Alloy Steel Corporation and Central Alloy Steel Corporation, after which he was for 10 years employed by the Steel and Tube Division of The Timken Roller Bearing Company as metallurgical engineer, specializing in alloy steel tubing applications in the various process industries.

He is well known for his work on the properties of metals at elevated temperatures and has contributed many articles to the literature on this subject.

Wilson is active in the affairs of the American Society for Metals, of which he is a former trustee, and in the American Society for Testing Materials, the American Society of Mechanical Engineers, the American Petroleum Institute and in the American Welding Society.

C. H. Stone & Company to Represent Kieley & Mueller

C. H. Stone & Company, 45 Arch Street, Boston, Massachusetts, have been appointed exclusive representatives in Maine, New Hampshire, Vermont, Massachusetts, Rhode Island and Connecticut, for Kieley & Mueller, of North Bergen, New Jersey, manufacturers of pressure and flow control equipment.

The Stone organization will represent K & M on its entire line of pressure regulating valves, back-pressure valves, liquid-level controls, strainers, steam traps, float valves, pump governors and power-plant equipment for all industrial applications throughout the New England area.

Dow Chemical Company Adds Two Sales Offices

Dow Chemical Company, Midland, Michigan, opened sales offices in Boston and in Philadelphia January 1.

Alexander Leith, Jr., who has been in the New York sales office since 1923, heads the Philadelphia office at 1400 South Penn Square. Alfred A. Lawrence, who has been with Dow since 1940, is

GRADUATE ENGINEER—with ten years broad supervisory and engineering experience in refinery and chemical plant maintenance, construction, design and operation available for superintendent or plant engineer. Address: Box 100, c/o Petroleum Refiner, Houston 1, Texas.

FOR SALE: Two 250 H.P. Vogt Boilers 120 pounds pressure allowed and 75 K.W. electric A.C. generator complete. Capital Ice Co., Indianapolis, Indiana.

FRASER-BRACE ENGINEERING COMPANY, INC.

Design, construction and installation of complete plants and projects

Mechanical, Heavy Industries, Shipbuilding, Hydro-Electric Developments, Power Plants, Chemical and Refining Plants, Process Industries, Metallurgical Developments and Processes, Explosives, Plastics, Water Supply and Treatment, Sewage and Industrial Wastes Treatment.

Reports - Appraisals - Consulting

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TO THOSE WE HAVE SERVED

in the past—we welcome a continuation of this pleasant business dealing.

TO THOSE WE HAVEN'T SERVED

we welcome the opportunity to show what we can do.

DISTRIBUTORS FOR:

TAYLOR Seamless Steel Welding Fittings, Seamless Steel Nozzles, Forged Steel Flanges • GLOBE Seamless Steel Boiler, Condenser and Still Tubes • YOUNGSTOWN Seamless Steel Butt-weld and Lap-weld pipe • FORGED STEEL Unions • JENKINS Valves • LAMSON & SESSIONS Bolts, Nuts and Rivets • WORTH Steel Plates and Heads for Mill Shipments Only • CROSS Perforated Plates and Sheets.

The CORBETT-WALLACE CORPORATION

Quality Products Plus Engineering Assistance

SAWYER AND WINTER STREETS

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PROTECTS QUALITY

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Time-Tested, Mileage-Proved

ADDITIVE FOR MOTOR OILS

Inhibits Oxidation and Corrosion Improves Sludge Dispersion

Available Without Restrictions

THE GLIDDEN COMPANY

ELMHURST, L. I., N. Y.

Tube Expanders

BY AIRETOOL

FOR TUBES ½" TO 12" I. D.

The above picture illustrates the many different size and type Expanders that are manufactured by Airetool.

Modern oil refinery technology makes it imperative that all joints be properly rolled. Airetool Tube Expanders have been developed to meet this specific demand. Their design, developed after research in the field, makes Airetool Expanders flexible and easy to operate. Careful precision workmanship of selected alloy steels assures extreme long life. For example: 546 tube ends of ½" wall thickness were rolled and flared by an Airetool Expander with but one set of rolls replaced. Learn all about these unusual expanders.

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FOR NEW EXPANDER BULLETIN

TUBE CLEANERS

Airetool Tube Cleaners quickly and efficiently remove deposits from tubes. This is because of Airetool's 28% more powerful motor; Airetool's new form alloy steel cutter heads. Airetool Cleaners are made for straight or curved tubes ½" to 24" I.D.

Write for Details
Dept. R

AIRETOOL MANUFACTURING COMPANY

AIRETOOL & YOST SUPERIOR FACTORY BLDGS.

SPRINGFIELD, OHIO

An up-to-the-minute Gasket Chart showing the cross-sections of 36 most popular Gasket Types, their purposes and the characteristics which fit them for the specific services intended, is now available to interested engineers.

This chart has been issued as the third in a series of technical papers on Gaskets compiled by the Research Laboratory of the Goetze Gasket and Packing Company, Inc., oldest and largest manufacturers of industrial gaskets in America.

In requesting copies of this and succeeding issues of "The Gasket," write the company on your business letterhead, mentioning your position.

GOETZE GASKET & PACKING CO., Inc.
8 Allen Avenue, New Brunswick, N. J.

Goetze for GASKETS

manager of the New England Sales Office, 20 Providence Street, Boston.

Leith, who graduated from Colgate University in 1919, obtained his masters degree from Columbia in 1921. During the many years he has been with The Dow Chemical Company he has handled sales of Dow's complete line of products in New York City and surrounding territory. Lawrence, before joining Dow, had long experience in textile finishing with the Cranston Print Works Company, Cranston and Webster, Rhode, Island.

Turco Products Opens Plant in Houston

Vachel Poole has been named general manager of the Houston factory of Turco Products.

Vachel Poole

This is the third plant now manufacturing chemical products for the company, which caters to the petroleum refining industry. Other plants are in Chicago and Los Angeles.

The company was started in the California city in 1927.

Ohio Injector Company Opens New Valve Plant

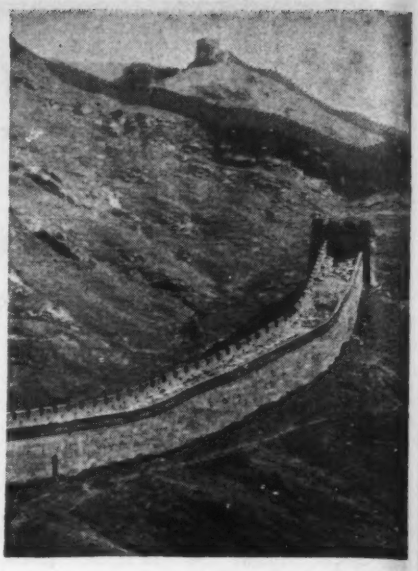
The new cast-steel valve plant of Ohio Injector Company at Wadsworth, Ohio, is now in full production with around-the-clock schedules to meet demand, officials of the company announced. It is equipped with the most modern precision equipment for the manufacture of cast-steel valves in keeping with standards of design and construction maintained by the company since its inception 60 years ago. The new plant contains a quarter million square feet of floor space. Production includes the complete range of gates, globes, angles and checks in the 150-pound series. The 300-pound series will soon be in production, followed by valves in the 400- and 600-pound series. The new executive building at Wadsworth, also recently completed, flies the first Army-Navy "E" pennant awarded to a member of the valve industry for outstanding achievement in the production of war goods, the announcement concludes.

Carbide Division Set Up By Allegheny Ludlum

Allegheny Ludlum Steel Corporation, Breckenridge, Pennsylvania, has acquired the property and business of Carbide Alloy Corporation, New York, which will be operated as a carbide division of the purchaser.

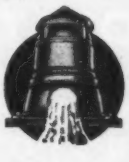
Initial products of the new division will be a line of highly developed cemented carbides, produced under processes established by Carbide Alloy Corporation.

Expansion into the carbide field is a reflection of intensive work in the field of cutting materials in general, W. F. Detwiler, board chairman, pointed out. Two research developments of undoubted importance to war production have preceded it: the introduction and subsequent free release to the nation of DBL high speed steel, which has been credited as the chief factor in the vital



The Great Wall of China
Built About 3000 B.C.

BUILT TO LAST
A LONG LONG TIME



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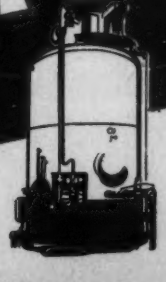

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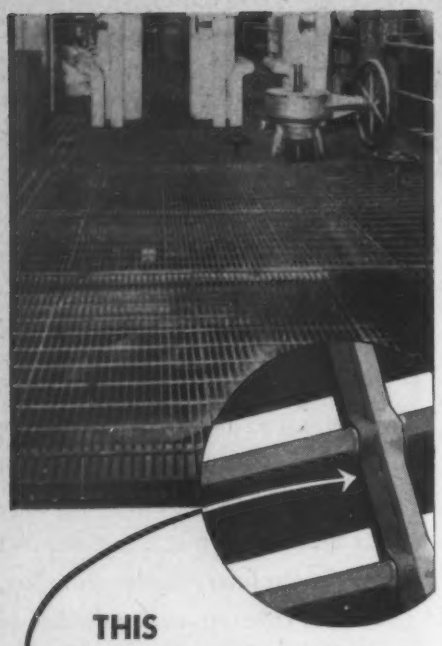

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tungsten conservation program; and the later development of the super DBL analysis, which carries the advantages of tungsten saving into the field of heaviest production cutting. In addition, Allegheny Ludlum was one of the prime movers in the development of the so-called "moly" high speed steels, which likewise have played a strong role in the war program.

Steve C. Maples Company Distributor for Quigley Products

Steve C. Maples & Company, Tulsa, Oklahoma, and Pampa, Texas, has been appointed distributor of Quigley products. The line includes refractory and insulating materials for the construction and maintenance of industrial furnaces, acid-proof cements, joint-sealing compounds, cleaning compounds and types of protective coatings.

Grinnell Joins Cochrane Steam Specialty Company

Joseph B. Grinnell has joined Cochrane Steam Specialty Company of Boston. He was a former associate of The Whitty Manufacturing Company and has also been connected with the electrical staff of one of the large Army installations in New England.

Charles T. Jansen With Wilmington Chemical Corporation

Charles T. Jansen, formerly assistant secretary of the Rubber Manufacturers Association, and with that organization for the past 14 years, has become associated with Wilmington Chemical Corporation, New York, as assistant to Edward V. Osberg, vice president. Jansen will be connected with the sales and promotional activities of the company.

Paul E. Floyd Back to Allegheny Ludlum Office

Paul E. Floyd has resumed his former position as district manager of Allegheny Ludlum Steel Corporation in Chicago.

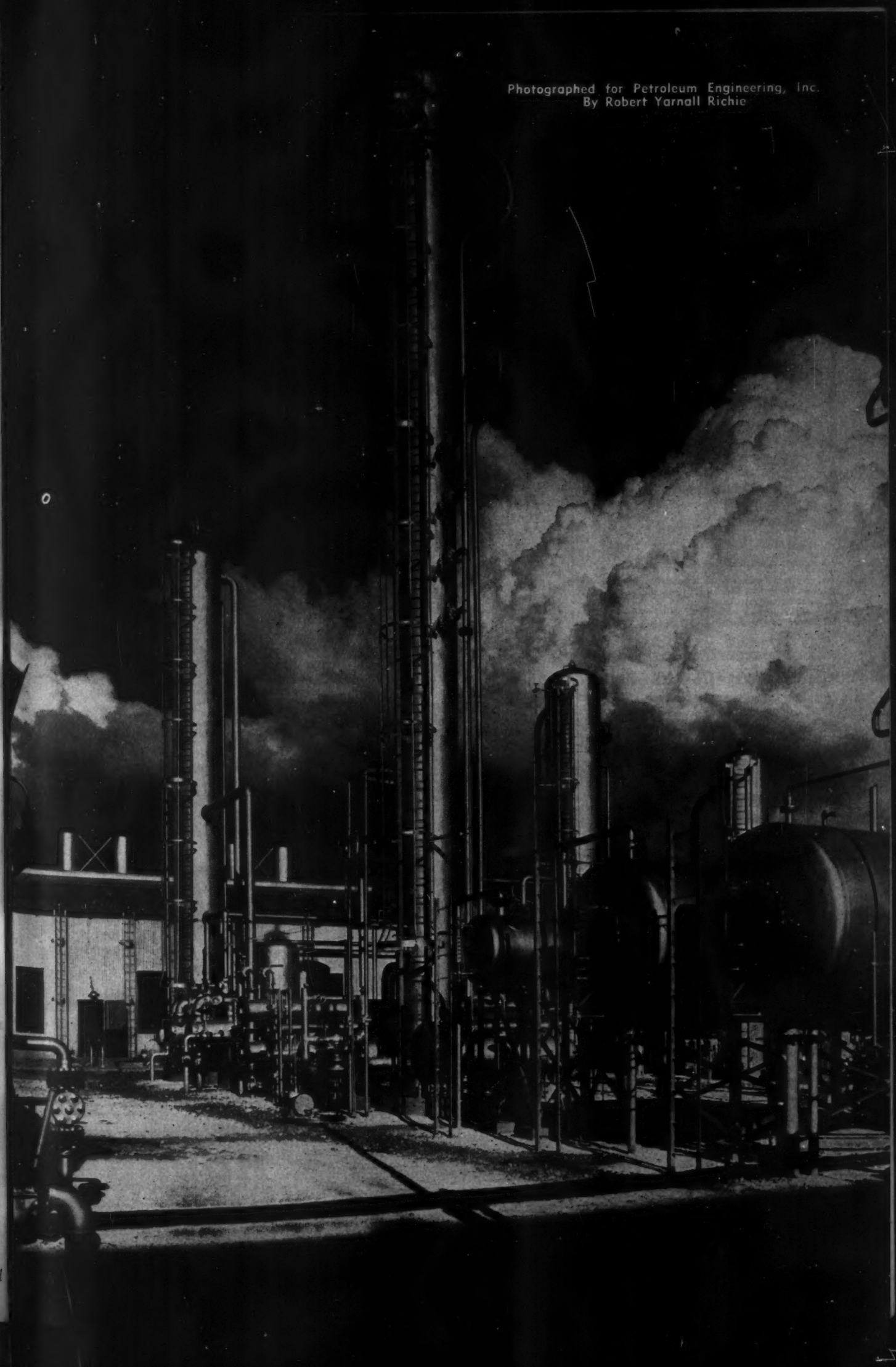
For more than a year he filled a responsible post in the Iron and Steel Branch of the War Production Board. The company granted him a leave of absence for the purpose in early 1942, at the war agency's request, and WPB recently consented to his release in order that he might return to active duty in his former capacity.

Rodolf Is Promoted by Gardner-Denver Company

R. H. Rodolf has been appointed manager of the pump and compressor division of Gardner-Denver Company, Quincy, Illinois, following the death of R. J. MacFarland. Rodolf's connection with the company dates back to 1917 when he joined the Canadian Rock Drill Company at Vancouver, then a subsidiary of the Denver Rock Drill Manufacturing Company. In 1926, he transferred to the St. Louis office as district manager. He continued in that capacity after the merger of Gardner Governor Company and Denver Rock Drill Manufacturing Company and was transferred to Quincy in 1939 as assistant manager of the Portable compressor and rock drill division.

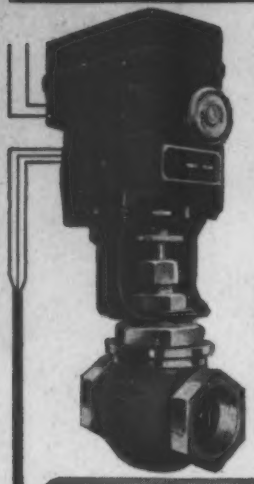
Appointed as Rodolf's assistant is C. M. George, who joined the organization in Quincy in January, 1929. With

A view of one of the several cycling plants designed and constructed by Petroleum Engineering, Inc. Manned by dozens of technicians skilled in their respective specialties, this organization is constantly at work . . . and has been for 15 years . . . taking over the processing problems of producing and refining property owners to design and erect natural gasoline plants, repressuring plants, vapor recovery plants, and "pure" hydrocarbon plants. Petroleum Engineering, Inc. Offices: Tulsa, Houston.



Photographed for Petroleum Engineering, Inc.
By Robert Yarnall Richie

atc HIGH SPEED MOTORIZED VALVES



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Use any standard temperature, pressure, flow or level measuring instrument equipped with "High" and "Low" contacts.

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★Complete Line

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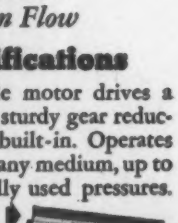

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the exception of a few months spent in the armed forces his service has been continuous in Quincy. Up to his recent appointment, he had been connected with the general sales department.

Lukens Steel Company Announces Personnel Changes

Robert H. McCracken has been appointed manager of combined sales of the Boston office of Lukens Steel Company and subsidiaries, By-Products Steel Corporation and Lukenweld, Incorporated, 131 State Street, Boston 9. He assumed his new duties September 1. He was formerly associated with Central Iron & Steel Company.

H. G. Austin, who has been assistant manager of sales for Luken in its Boston office, has been appointed assistant manager of combined sales of Lukens, By-Products and Lukenweld.

Harry G. Porch, manager of sales since 1900 in the Boston office, retired from active duty September 1, after 48 years of continuous service. Miss A. L. Hill, who has been secretary in the Boston office for 27 years, will continue in that capacity.

Wheelco Company Expands Sales Organization

Wheelco Instruments Company, Chicago, announces the following additions to the company's sales and service organization:

New England representation has been strengthened by appointment of the Cochrane Steam Specialty Company, Boston, to serve with George W. Hall, the company's present representative. The Cochrane organization and Hall now serve Massachusetts, Rhode Island, Maine, New Hampshire, Vermont and parts of Connecticut east of the Connecticut River.

C. L. Clark, formerly attached to the company's Cleveland office, has been placed in charge of a Western New York office in Buffalo. Charles D. Mount has been named sales and service representative for Southern Ohio and Northern Kentucky, making his headquarters in Cincinnati, while H. E. Holling has been appointed northwestern Illinois representative with headquarters in Peoria.

The Lang Company, Salt Lake City, has been appointed sales and service representative in Utah, Idaho, Wyoming and Nevada.

Irwin, Key Figure in the Diesel Engine Field, Dies

William G. Irwin, one of the key figures in the development of the Diesel engine industry, died December 14, in Indianapolis. During the last war, in 1918, Irwin had in his employ, as a chauffeur, a young man whose ambition it was to develop a high speed Diesel engine suitable for trucks, buses, small boats and other types of mobile equipment too small to accommodate the larger type engines. The young man's name was Clessie L. Cummins. Irwin became convinced of the soundness of the young man's ideas and gave freely of his encouragement and financial backing. The Cummins Engine Company grew from this early association. Irwin was chairman of the board of directors of this company and was continuously active up to the time of his death. He participated in many industrial, financial, political, educational, religious and philanthropic activities.

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